Applying Behavioural Science to Communication to Encourage Cooperation in Social and Intrapersonal Dilemmas

Julia Kolodko

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Declaration of Originality

The work presented in this thesis (including data generated and data analysis) was carried out by me, except in the cases outlined below.

Research presented in Chapter 2 was conducted in collaboration with Rebecca McDonald.

- JK: Conception of study. Development of interventions. Study design. Intervention implementation. Data analysis and interpretation. Lead on article drafting and revisions.
- RM: Co-development of intervention.

Research presented in Chapter 3 was conducted in collaboration with Philippa Nation, as part of my supervision of her MSc dissertation.

- JK: Conception of study. Development of interventions. Study design. Intervention implementation. Data analysis and interpretation. Lead on article drafting and revisions.
- PN: Co-development of Study 2.1 statements. Study 2.1 data analysis and interpretation.

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Abstract

This thesis examines how behavioural science can be used in communication to promote cooperation in social and intrapersonal dilemmas. Specifically, it presents three research projects, one aimed at improving health choices and two aimed at encouraging people to act pro-environmentally. The objective of the first study was to test whether making health consequences of healthy/unhealthy foods and drinks salient would make people more likely to choose healthy options. This manipulation relied on a well-researched *hidden zero effect* and aimed to apply it in a more real-world context. Results were inconclusive, with the manipulation having a significant impact on choices made in an online experiment but not in a follow-up field experiment. The other projects aimed to evaluate the effectiveness of a behavioural change framework, i.e. the Behavioural Change Wheel (Michie, Atkins & West, 2014), in communication and environmental decision-making. The aim of the Twitter project, described in Chapter 3, was to encourage participants to tweet anti-littering messages. The interventions had a significant impact on intent to tweet and actual behaviour. I developed and describe a novel tool that allows one to measure real behaviour and merge online academic research with social media. The last project was conducted in collaboration with LitterGram, an anti-littering start-up. I developed an e-mail-based intervention, aimed at encouraging users to use the app more, with the objective of establishing a desired social norm of clean public spaces. The intervention was effective in increasing usage. Together, these three projects indicate that it is possible to influence behaviour through the means of written communication, in online settings and outside of the context of public policy. This work provides new tools and methodologies of how to conduct such research methodically and relying on behavioural science theory. Implications, limitations and directions for future research are discussed in Chapter 5.

CHAPTER 1

Introduction

A World of Dilemmas

Some of the biggest problems the world is currently facing have a common structure: the individual is personally better off acting in a selfish, short-sighted manner, while collectively, as a society, we are better off if individuals choose less selfish options. Personally, each of us is better off using as much gas and electricity as we want, while global deposits of natural resources shrink, leaving less for future generations and causing global warming; each of us is also better off littering, as it's often difficult to find a bin, while the society and the natural environment suffer (Kolodko & Read, 2018). In these situations, we want society to bear the consequences. We want what's good for us, enjoying the comfort of driving everywhere, while we want others to do what's best for society and to use public transport so that *we* can drive on roads with no traffic and live in a place with clean air. The key feature of these types of problems, known as social dilemmas (Dawes, 1980; Liebrand, Messick & Wilke, 1992; Platt, 1973; Schelling, 1978), is that each individual receives a higher payoff for defecting than for cooperating, but society is better off if everyone cooperates than if everyone defects.

This social dilemma framework for understanding and analysing problems can be applied to another group of decisions, known as intrapersonal dilemmas (Read, 2001). Because of hyperbolic discounting (Frederick, Loewenstein & O'Donoghue, 2002), each of us can be "divided" into a society of different selves – past, present, future – with different, often conflicting, preferences. As a consequence, what we want now is not necessarily what will be best for us in the future. More formally, intrapersonal dilemmas are situations in which the person's instant utility and her total utility (Kahneman & Snell, 1990, 1992; Kahneman, Wakker & Sarin, 1997) are at odds.

Within this framework, problems such as dieting, procrastination or saving for retirement become dilemmas too. Specifically, a choice is said to be an intrapersonal dilemma if a decision a person is making at a point in time is beneficial to her at the time of making while being suboptimal or

detrimental in the long run, to her "society of future selves". If I choose to binge eat during the holidays, I make my present self happy – allowing it to indulge in as many of the favourite holiday treats as it wants. I then leave my future, post-holiday selves to deal with the consequences of having to burn off the excess calories and lose the holiday weight.

The analogy between the two types of dilemmas is, of course, not perfect. There are several components of any dilemma – (1) the decision-maker; (2) the people/selves her decision has an impact on; (3) the preferences of these stakeholders; and (4) the issue of possible time discounting. While all intrapersonal dilemmas will have consequences delayed in time, not all social dilemmas will, as decisions a person makes can impact the society at large at the time of making, such as in the instance of driving to work and resulting traffic during rush hours.

Another key difference is that in social dilemmas the decision-maker faces a choice that impacts the well-being of other (real) people. Conversely, in an intrapersonal dilemma, the decision-maker faces a choice that impacts the well-being of her future selves. Since those future selves are (a part of) who the person is, she may identify with them more and thus may be more willing to do "the right thing".

The contrary can also be true. Since an intrapersonal dilemma will involve a time delay and a social dilemma may not, it is possible that the decision-maker's preferences will be more aligned with those of society than of her distant future selves. In short, while both in the case of social and intrapersonal dilemmas there is a conflict of interest, possible time delay, identification and concern with who may suffer the consequences of such a decision can vary.

Despite these differences, enough important similarities can be drawn between the two types of dilemmas to warrant a similar approach to confronting these issues through the use of behavioural science. Indeed, behavioural scientists have been working on applying their knowledge to address exactly these types of problems (e.g. Behavioural Insights Team 2016; 2017; OECD, 2017; World Bank, 2015). This thesis describes three such projects – one aiming to address an intrapersonal dilemma of unhealthy eating and two addressing a social dilemma of littering – and which aim to

tackle these issues through the application of behavioural science insights and theory to communication, in a simple and easy-to-implement way.

Common Themes of the Three PhD Projects

Theme 1: Dilemma Type

What the three projects in this thesis have in common is not only that they all address a social/intrapersonal dilemma but that they address the same *type* of dilemmas, drawing yet another similarity between those two class of behavioural problems. Platt (1973) distinguished three types of intrapersonal dilemmas. The first subgroup are problems that involve *time delay*, i.e. when a pleasurable behaviour, such as eating, has negative long-term consequences, for example obesity, which, due to time delay, are disregarded. The second subgroup is that in which the problem is *ignorance*, i.e. when a person doesn't know her behaviour has detrimental effects. Finally, the third subgroup, called *sliding reinforcers*, involves decision situations in which the benefit decreases steadily with repeated behaviour until it becomes punishing, such as in the case of recreational drug use that develops into an addiction.

The same framework can be applied to social dilemmas, including littering. A person may find it easier (more attractive) to litter than to use bins while, at the same time, disregarding long-term consequences of littering (*time delay*); or one may litter because of *ignorance*, i.e. lack of knowledge of how litter impacts the natural environment or what costs it imposes on public finances. Likewise, the mechanism of *sliding reinforcers* can be of relevance. A person who only litters occasionally may, with every wrapper she drops, get accustomed to doing so until it becomes a habit (rather than an addiction) and she turns into a “heavy” litterer who never uses bins. With time, enough litter can pile up in a person’s environment that the negative consequences eventually start to bother her as well, turning an initially beneficial behaviour of not having to look for a bin into a punishing

one of having to live in a foul-smelling and unsanitary neighbourhood or home.

Each of these three subgroups, or a combination thereof, imposes a different angle to further problem analysis and solution development. In my work, I assume people know their behaviour undermines the long-term well-being of their future selves or others (lowers the total utility) and I focus specifically on *time delay* problems, putting *ignorance* and *sliding reinforcers* aside. First, such an approach makes all interventions based on education redundant, since it assumes that people know their behaviour, while pleasant (easier), can have long-term detrimental effects.

However, education is not to be confused with reminders. Some of the studies described in the following chapters, most notably Hidden Consequences in Chapter 2 and LitterGram in Chapter 4, do use messages related to the consequences of one's behaviour, which could be considered educational. Nonetheless, it is merely an act of providing reminders, with an assumption that people know the consequences of their behaviours, they may just not remember about them often enough and at significant times.

Second, this approach simplifies the issue at hand, by putting aside the problems of physiological or emotional addiction (where relevant). I am therefore left with a subcategory of intrapersonal and social dilemmas, in which people act in a way that is suboptimal for them or society in the long run, are aware of it, and do it anyway.

Theme 2: Communication and Simplification

The next similarity of the three PhD projects is that they use written communication to influence choice. One of the objectives of my work was to test the effectiveness of *simple* behavioural change interventions. In this context, "simple" can mean several things. First, there is the perspective of the person, or people, whose behaviour is attempted to being influenced. In this case, a "simple intervention" can mean an intervention that is naturally integrated with one's environment. An example of such an intervention would be to serve food on smaller or differently coloured plates, which has been shown

to reduce the amount of food people eat (Van Ittersum & Wansink, 2011). Conversely, a "complex" intervention would be one that introduces additional objects, tools or channels of communication to the decision-making environment, such as providing people with feedback via e-mail or letters (e.g. Petersen et al., 2007) or hanging a poster with eyes "overlooking" a person (e.g. Keep Britain Tidy, 2014a).

Another way simplicity can be understood, from the recipients' point of view, is whether an intervention uses the central or peripheral route of persuasion (Petty & Cacioppo, 1986). In this context, a simple intervention will be one that does not require a decision-maker to analyse information presented to her, i.e. it will *not* use the central route. It will engage System 2 (Evans, 2008; Kahneman & Frederick 2002; Stanovich 1999) in a minimal way, if at all. Rather, a simple intervention will persuade through the peripheral route, relying on heuristics such as the attractiveness or likeability of the messenger.

This research, however, focuses on simplicity understood from the perspective of designers of choice environemtns – a term I use broadly here, after Thaler & Sunstein (2008), to mean anyone, from policy-makers, through social marketers, to organisations and individuals, who use, or want to use, behavioural science approach to tackle social and intrapersonal dilemmas.

In this case, simplicity relates to the process of intervention design, implementation and evaluation. A simple intervention, therefore, can mean one that uses few, ideally only one, behavioural change techniques (BCTs; Michie et al., 2008; Michie et al., 2013). With the development of behavioural, science- and evidence-based approach to policy-making in the last decade, interventions have been getting increasingly complex and methodical, using many different BCTs, rather than just one. Yet a more complex approach does not necessarily mean a more effective intervention. As meta-analyses conducted by Dombrowski et al., (2012) and O'Brien et al. (2015) show, increasing the numbers of BCTs is not associated with better intervention outcomes.

Finally, simplicity in behavioural change can relate to resources – time, money, human – needed to develop, implement and evaluate the

impact of an intervention. My research focuses on this aspect of simplicity, in an attempt to develop ways of designing and implementing behavioural change interventions, as well as measuring their impact that would allow one to test and deliver interventions in a quicker and more efficient way.

This aspect of simplicity relates to the practicalities of using behavioural science in the field and seems more important now than ever. With the ever-growing presence of intrapersonal dilemmas such as overeating (Mokdad et al., 2000; WHO, 2016; 2017) and social dilemmas such as littering (Keep Britain Tidy, 2015), behavioural scientists, who have the knowledge to tackle these issues, need to be able to find quick and efficient ways of nudging specific behaviours in the contexts in which they arise. These nudges should not require months or years of preparation and enormous budgets. They should be, as Martin, Goldstein and Cialdini (2014) called it, "the small big", meaning *small* changes that have an impact.

Central to this is the issue of reproducibility in science and how context-dependent behavioural change interventions can be – the fact that something worked in one domain, place or at one time does not mean it will necessarily work in another (Behavioural Insights Team, 2016b; Open Science Collaboration, 2015). Ineffective behavioural change techniques continue being used, while effective ones can be difficult to replicate, are underused or their mechanisms of action aren't well understood (Michie & Johnston, 2012; Open Science Collaboration, 2015). Moreover, evidence on intervention effectiveness is accumulating slowly, partially because they are so complex (Craig et al., 2008; Michie & Johnston, 2012). This is another reason why a simple approach may be of benefit. It can allow choice architects to implement more interventions, to more easily measure their results and to do this in less time.

All this is, of course, not to say that complex interventions are unnecessary or a wrong way to go. Depending on the specifics of a problem being addressed, where an intervention is to take place, who delivers the intervention and whom it targets, it may be the case that a complex approach is optimal. Yet, sometimes more can be achieved if, in place of one complex intervention, several simpler ones are introduced; or, in instances when a complex intervention cannot be implemented at all, a simple alternative is

chosen. Such approach could lead to a wider use of behavioural science in the field, especially by those working outside of the public sector, in which one has influence over policy and legislation.

For these reasons, research presented in this thesis uses communication (*Communication/Marketing* policy category in the Behavioural Change Wheel framework; Michie, Atkins & West, 2014) to deliver interventions, rather than other policy categories, such as providing *Guidelines*, *Regulation*, *Legislation* or even *Environmental/Social planning*.

One could argue that communication is not the best channel to deliver interventions, as it requires a decision-maker to process at least some of the information (i.e. to see/hear a message and to encode at least some aspects of it), suggesting that a communication-based intervention will not, indeed, merely use the peripheral route of persuasion. However, as previous research suggests (see Chapter 2 and Chapter 4 introductions), communication can be an effective channel through which behavioural change interventions can be delivered.

Moreover, for most private organisations, communication is the only, or the most practical, tool of persuasion. With the widespread use of communication in social marketing, the ubiquitous social media platforms, websites, e-mail/newsletter communication, it seems justified to attempt to bring more of behavioural science to communication and more of communication to behavioural science.

Any intervention – especially one that is methodologically well-developed and evidence-based – will be better than no intervention, even if, in theory, a policy-based intervention would be more effective. The approach presented in this thesis is about working with available resources, not in an ideal world, with the hope that it leads to more research exploring the application of behavioural science outside of academia and public policy; to results of such work being published; to the development of communication-based interventions; and finally, to a wider use of the behavioural approach in the field of social marketing. All issues that are further discussed in the concluding chapter (see Chapter 5).

Theme 3: Theory-Informed and Evidence-Based Approach

Simplification, however, is not to be confused with poor methodology. The final aspect that connects the three research projects is that, while promoting a simple approach, they are theory-informed and evidence-based. My aim is to encourage existing and aspiring choice architects, who see the potential in using behavioural science to address the social and intrapersonal dilemmas they deal with, to think "simple" but also evidence-based at the same time.

Previous research indicates that interventions rooted in theory and evidence, as opposed to those relying merely on intuition, are more effective (Noar & Zimmerman, 2005; Webb et al., 2010). While the aim of this work was simplification of the application of behavioural science theory and insights and the process of impact measurement, it was not at the cost of validity or reliability. All interventions described in this thesis are rooted in theory and are evidence-based. In other words, simplification relates only to the mode of delivery and practicalities of intervention development and impact measurement, not to the precision of methodology design or the quality of measurement of their effects.

Theme 4: Developing an Approach, not Solving a Problem

Finally, it is important to distinguish between the goal of developing a working field intervention and solving a problem, as opposed to the goal of outlining and showcasing different ways behavioural science can be applied in communication and how one should approach such work. The objective of my work was the latter – it was not to solve any particular problem in this instant and with my PhD work alone. Rather, it was to outline, develop and test ways in which behavioural science could be used by those working in, for example, social marketing. For many organisations whose aim is to tackle social issues, including, for example, LitterGram, a start-up I collaborated with on one of the projects (see Chapter 4), communication is the main mode

of persuasion. Hence, exploration of and research into how behavioural science could be practically applied in this context, including the development of new measurement tools (see Chapter 3) and designing methodologies that use e-mail-based newsletters to quickly and practically deliver interventions (see Chapter 4), is needed.

Thesis Overview

This thesis consists of three projects, each described in its own chapter. The three chapters were written as separate papers, with the aim of being published. Subsequently, any overlaps between the papers are intentional, as the aim was for each one to be a complete work on its own.

Hidden Consequences Project Overview and Objectives

The objective of the first research project (from here on referred to as "Hidden Consequences"; see Chapter 2) was to test whether making health consequences salient would make people more likely to choose healthy, rather than unhealthy, snacks and drinks. This relied on a simple communication-based manipulation and applied findings from previous research on *hidden zero effect* (Magen, Dweck & Gross, 2008; Read, Olivola & Hardisty, 2016) to a more real-world problem.

The project consisted of two experiments: an online experiment in which people made hypothetical choices between food and drink pairs, composed of healthy and unhealthy items (Study 1); and a follow-up field study (Study 2) in which participants were offered (real) healthy and unhealthy snacks. In both experiments, choices were framed in different ways, either reminding participants of health consequences of the healthy and/or unhealthy items or not mentioning these consequences. The hypothesis put forward was that people who were reminded of either (healthy or unhealthy) consequences would be more likely to choose the healthier options. Results of Study 1 confirmed the hypothesis. However, I was not able to reproduce the effect in Study 2, an issue further discussed in Chapter 2.

Twitter and LitterGram Project Overview and Objectives

In the other two research projects, I applied a theory-based behavioural change framework, the Behavioural Change Wheel (BCW; Michie, Atkins & West, 2014) to pro-environmental behaviours, and specifically to encourage people to tweet anti-littering messages ("Twitter" project; see Chapter 3) and to encourage a community of anti-littering smartphone app users to use the app more ("LitterGram" project; see Chapter 4). In both studies, interventions were delivered through communication; and while in these studies some of the interventions were composed of several, rather than one, BCTs, they were still considered simple as, thanks to innovative ways of delivering the interventions and measuring their impact, they allowed for an easy and quick application of behavioural insights in the field.

The secondary objective of these two projects was to add to the recently developing body of evidence on the effectiveness of theory-based interventions. While there is some evidence that theory-informed interventions are more effective than intuition-based ones (Webb et al., 2010), the evidence relates mostly to the use of theory of planned behaviour (Ajzen, 1985, 1991; Ajzen & Madden, 1986). There is little evidence that interventions based on the Behavioural Change Wheel, which is becoming a popular framework in behavioural change research (concluded based on the number of publications that mention the BCW; three in 2014, seven in 2015, 16 in 2016, 10 in 2017 and 13 in the first nine months of 2018), are more effective than if one were to select techniques based on intuition or previous research findings (e.g. as done in Hidden Consequences). Indeed, there is still little evidence that such interventions are effective at all (see Chapter 3 introduction for literature review). Twitter and LitterGram studies are, to my knowledge, one of the first studies to report results of the BCW-based interventions, rather than merely describing the process of problem diagnosis and intervention design.

Contribution

This work contributes to existing behavioural science literature, its application, practicability and development, in several ways. Generally, as explained in detail earlier, all three projects aim to apply behavioural science insights to communication, rather than using environmental restructuring, legislation or policy (or any other of the policy categories listed in the Behavioural Change Wheel). This is intentional as communication is a widely used tool of influence among those *not* working in the public sector, where one has an influence over policy and legislation. It seems that currently most evidence-based behavioural science application takes place within governments and other public institutions or institutions that have strong ties with the public sector (e.g. Behavioural Insights Team 2016b; 2017; Sousa Lourenco et al., 2016; OECD, 2010; 2017; World Bank, 2015), with some governments outlining how exactly they aim to use such an approach in their work (e.g. Australian Public Service Commission, 2013; HM Revenue and Customs, 2013). It appears, however, that such an approach is much less used among NGOs, start-ups and private pro-social organisations. Yet, as discussed earlier, the number, scale and severity of social and intrapersonal dilemmas that need solving is so vast that it seems crucial to make behavioural science more applicable to non-policy contexts and, subsequently, more widely used. This can be done by developing methods – from simple framing techniques such as in the Hidden Consequences study; through testing new behavioural change techniques and developing novel behavioural measure tools, as in the case of the Twitter study; to outlining how the behavioural approach can be used in e-mail communication with a company's newsletter subscribers, as showcased in the LitterGram study – that show how to use this knowledge in communication; communication, as it is a basic tool of interactions and influence among people (Fischer, 1987) and widely used in social marketing.

The second general contribution, which also relates to the issue of applicability of behavioural science, is that in all the studies I take existing insights (either in the form of a well-researched effect, the *hidden zero effect*; or in the form of a leading theory-based framework, the Behavioural Change

Wheel) and apply them in a practical, real-world context. To my knowledge, Hidden Consequences is only the second study (after Read, Olivola & Hardisty, 2016) to apply the *hidden zero effect* to the context of non-monetary choices, and the first one to attempt to use this insight to influence real choice. The other two studies – Twitter and LitterGram – also contribute practically, as they aim to outline how a complex theory-based framework can be used in the field by diverse organisations, even small start-ups such as LitterGram, and how one can measure changes in real behaviour, rather than intent, without the need to set up large field studies.

Each of the three projects has a contribution on its own, too. The Hidden Consequences project takes a well-researched insight, the *hidden zero effect* (Magen, Dweck & Gross, 2008; Read, Olivola & Hardisty, 2016), and applies it to a more real-world context of (un)healthy eating, identifying a way to nudge people to eat more healthy by means of a simple linguistic cue, which could be applied on a mass scale, for example in menus, on wrappers, cafeteria signs and displays, in a relatively cheap way.

Twitter and LitterGram projects are among the very first studies to apply the BCW to a non-medical decision-making context and, more importantly, to (1) use the framework to diagnose the barriers to behavioural change, (2) develop and implement interventions and (3) to report results of their effectiveness.

Both these studies outline a unique approach to conducting and measuring behavioural change. In the Twitter study, I designed a novel way of measuring real behaviour in a simple, efficient and cost-effective way, through the use of a Qualtrics – Twitter interface, which merges online experimental research with social media. This methodology could be used by other researchers, as well as encourage those working in social marketing and social media to use online research platforms, in order to reliably measure the impact of their work.

Additionally, in the Twitter project, I developed two new behavioural change techniques, for a BCW domain for which there were no BCTs, which – if effective – could be added to the framework. In LitterGram, the intervention was delivered via a series of newsletters, providing an example of how BCW-derived behavioural change techniques can be used in e-mails.

Overall, the aim of this work is to emphasise the importance of applicability of behavioural science outside of public policy and to provide examples and initial evidence on how this can be done, and to generate social impact. This contribution is, therefore, more practical than theoretical in nature, nonetheless all the research is theory-based. This contribution also aims to be simple in nature, yet all research is evidence-based. The main aim is to make behavioural science theory more easily applicable outside of public policy and in the field of social marketing and communication so that academia, and behavioural science in particular, can contribute much more to addressing social and intrapersonal dilemmas.

CHAPTER TWO

Consequences hidden in the foods that we eat:

Influencing dietary choices by making health consequences salient

Introduction

Today, more people die of noncommunicable diseases such as diabetes, cancer and cardiovascular diseases than of any other cause (WHO, 2017a). These diseases are a result of our dietary choices, especially excess calorie, sugar and sodium consumption (WHO, 2017b); choices, which are not a result of food shortage or lack of alternatives but of overabundance and everyday decisions we make (United Nations, 2011); choices, which can be influenced, changed and improved.

Behavioural science research shows that changes in choice architecture – how decision problems are designed or framed – can improve people's eating habits (Hollands et al., 2013a; 2013b; Thaler & Sunstein, 2008). Aspects of physical and social context in which decisions are made, such as the size of a plate on which food is served or how it is arranged or displayed, influence what people choose. Hollands et al. (2015) conducted a meta-analysis of 58 studies that looked at the influence of plate size, packaging size and a serving portion on the number of calories consumed. They found that exposure to larger size portions, packages or plates increased the quantity of food consumed by children and adults.

Another example of how choice architecture can influence health decisions is the impact food arrangement, for example in cafeterias or in stores, has on people's dietary choices. Hanks, Just and Wansink (2013) were able to increase fruit and vegetable consumption by 18% and 25%, respectively, among students from two New York state high schools, by making these foods more easily accessible; making them seem more attractive, e.g. by changing food labels; and by making the selection of fruit and vegetables seem normative, e.g. by having lunchroom staff recommend these healthier options. Similarly, Nakamura et al. (2014) showed that a simple re-arrangement of where drinks were displayed in a grocery store influenced sales of alcoholic and non-alcoholic drinks.

Communication as Choice Architecture

Research on the impact of framing – the effect of how choices are presented and communicated – shows that behaviour can also be changed by changing how a decision problem is presented. How a problem is framed was shown to influence health-related behaviours such as engagement in early disease detection (e.g. Apanovitch et al., 2003; Banks et al., 1995; Cherubini et al., 2005; Garcia-Retamero & Cokely, 2011; Meyerowitz and Chaiken, 1987; Rothman et al., 1999) or addictive behaviours (Fucito et al., 2011; Moorman & Putte, 2008). A review of 93 studies, performed by O'Keefe and Jensen (2007), found that, in disease prevention messages, gain-framed appeals, which emphasize the advantages of compliance with a recommendation, were significantly more persuasive than messages emphasizing the disadvantages of noncompliance. Similarly, Witte and Allen (2000) analysed 93 studies and found that public health campaigns that used strong fear messages resulted in high levels of perceived severity and susceptibility and were more persuasive than weak fear messages.

There are other ways than framing messages as gains or losses to influence choice through communication. For example, in a series of field experiments, Michael Hallsworth (2017) showed that deterrent messages emphasizing the threat of sanctions increased compliance in the domains of health decision-making (reducing missed hospital outpatient appointments and reducing unnecessary antibiotic prescriptions by general practitioners) to a greater extent than non-deterrent messages, which emphasized factors such as social norms. Hinojosa et al. (2009) showed that teenagers could be encouraged to eat healthier by framing healthy eating as a pro-social behaviour, rather than by simply explaining how the body used such foods for energy. Finally, Singapore Health Promotion Board (2016) was able to effectively nudge consumers towards choosing lower calorie meals by the use of framing. Over 1500 food and beverage outlets participated in the programme, in which meals under 500 calories were clearly labelled as healthy, by putting a *Healthier Choice* symbol next to them in menus. Participating restaurants were able to double the sales, to approximately 1.1. million, of these meals.

Hidden and salient opportunity costs.

One more example of how behaviour can be influenced by a simple change in choice frame, which inspired my line of research, is salience of opportunity costs. From an economic point of view, every decision what to eat is a trade-off between a certain option and its opportunity costs. For example, if we choose to have an indulgent luxurious breakfast, we miss out on the opportunity to be abstemious; while if we are abstemious, we miss out on the opportunity to have a luxurious breakfast.

Of course, the choices we make in the real world are a bit more complex. Every decision can have multiple alternatives, which are foregone the moment a choice is made. For example, when we choose to eat a luxurious breakfast, the opportunity cost is being abstemious, but also other available breakfasts that may be healthier, smaller or just mundane. Moreover, opportunity costs can also be less tangible, such as the impact a meal has on one's health. Every meal is a decision and a chance to think of and evaluate such costs and benefits and to pick the option that yields the highest value. But is that what people do?

Previous research suggests that people often disregard opportunity costs and that simple reminders can change the perceived attractiveness of available options, nudging people to be more patient and to make better decisions. For example, Frederick et al. (2009) showed that reminders that buying a cheaper of two products would leave a person with "extra money" increased the likelihood of that person purchasing the cheaper product. In another study, Chatterjee and colleagues (2016) showed that when people were choosing between experiential goods, reminders of time opportunity costs influenced choices and people tended to choose the option that let them save time; while when they were choosing material goods, reminders of financial opportunity costs influenced choices and people tended to choose the option that let them save money.

Research on the so-called *hidden zero effect* also shows that simple reminders of even quite obvious opportunity costs can change people's preferences and behaviours. Magen et al. (2008) found that participants who were faced with an intertemporal choice problem and who were reminded

of opportunity costs of their choices (i.e. that they would get no money later if they choose some amount of money straightaway; or that they would get no money now if they chose to receive some amount of money later) were significantly more patient than participants who were not reminded of these "hidden zeros".

This finding was further explored by Read, Olivola and Hardisty (2016), who explained this bias towards smaller, immediate benefits with different levels of salience of opportunity cost – opportunity costs of later consumption being more salient than those of earlier consumption since they bared at the time of decision-making. In a series of experiments, they showed that highlighting opportunity costs of larger, later rewards did not affect patience; but highlighting the less salient opportunity costs of smaller, sooner rewards increased patience – what they called an asymmetric subjective opportunity cost hypothesis. Similar results were earlier reported by Loewenstein and Prelec (1991; 1993), Magen et al. (2014), Radu et al. (2011), Read and Scholten (2012) and Wu and He (2012).

Research Question

The objective of my experiments was to test whether a take on the findings from the previous opportunity costs salience research could be applied in a more real-world context of health decision-making and, specifically, to what people chose to consume. Most previous studies used monetary choices (Magen et al. 2008, 2014; Radu et al. 2011; Read and Scholten 2012; Wu and He 2012). To my knowledge, only Read, Olivola and Hardisty (2016) used non-monetary choices in one of their experiments. Yet, there are no studies that looked specifically into the impact of opportunity cost framing in the domain of healthy eating, while, in our everyday lives, this is a type of decisions we make very frequently and a type of decisions that have detrimental effects on our health, lifespan and well-being (United Nations, 2011; WHO, 2017b). Moreover, in this study, I highlighted the less tangible opportunity costs – effect on health – rather than the alternative, not chosen, items, as the previous studies have done.

The question I put forward was whether reminding people of opportunity costs associated with their consumption choices could act as a nudge and would make them want to consume healthier options. Specifically, I wanted to see if people would be more likely to choose healthy foods and drinks if they were reminded of the effects these products had on their health and if this approach could become a behavioural change technique choice architects could use in nudging people to eat more healthily.

Study 1

In the first experiment, I investigated the effect of making health consequences salient in a series of hypothetical choices. Respondents were asked to choose between pairs of foods and drinks – each pair being composed of a healthy and an unhealthy item. I hypothesized that making health consequences salient would encourage people to choose healthy options more often, irrespective of whether the consequences were mentioned for the healthy *or* unhealthy options.

Methods

Participants.

Participants were recruited through Prolific Academic, an online platform in which people can participate in online experiments in exchange for a small payment. In line with the new statistics approach (Cumming, 2014), sample size was chosen based on a power calculation, using data from Read, Olivola and Hardisty (2016). Using effect sizes from their studies (Study 1 d=0.51; Study 2 d=0.47), I estimated the sample size to be between 62 and 73 per experimental group. However, since in this study people made choices between foods and drinks, I wanted to be able to eliminate from the analysis, if necessary, pairs that included items people said they would never consume (e.g. due to allergies). Therefore, I increased the sample size to 110 per group. A total of 550 respondents took part in this experiment (mean age=40.24; 64% female). Due to differences in the names of certain foods

between the UK and USA (e.g. crisps vs. chips), I restricted the sample to UK residents only. Participants were paid £1.50.

Procedure.

Participants were randomly assigned to one of five experimental groups. They made 13 hypothetical choices, between six food pairs and seven drink pairs, as shown in Table 1. Since the healthiness of many foods and drinks depends not only on what one consumes but also on the quantity consumed (e.g. a glass of wine a day is said to be healthy but a bottle a day is probably not), I described the items in a way that implied a serving size. I concluded that some items had an "assumed" serving size. For example, a salad usually implies a bowl of salad; bananas and apples are typically of a similar size. On the other hand, items such as ice-cream or crisps can come in small, single-serving packages or huge, family-size ones. They can easily become "domino foods" on which one binge-eats. Therefore, for these products, I added relevant serving size information, such as "a bowl of ice-cream" or "a packet of crisps".

Each pair was composed of a healthy and an unhealthy item, selected based on the results of a pre-test, in which 221 respondents evaluated the healthiness of 30 food and 30 drink items. The pre-test list was composed of 10 foods and 10 drinks that I evaluated as healthy, 10 foods and 10 drinks evaluated as average and 10 foods and 10 drinks evaluated as unhealthy. Respondents rated the healthiness of all items, confirming most of the initial evaluations. They also rated the likelihood with which they would consume these items. Based on the data, I chose 12 food items and 14 drink items, which made up six food and seven drink pairs, composed of healthy – unhealthy options, which people were more, rather than less, likely to consume.

The perceived healthiness of the 26 items used in Study 1 was re-checked (see Table 1). All healthy items were evaluated, on average, as healthy (a mean of 4.66 for food items and 4.37 for drinks, on a 5-point scale, where 5 was "very healthy"). Likewise, all unhealthy items were

evaluated as such (a mean of 1.79 and 1.86 for foods and drinks, respectively, where 1 was “very unhealthy”).

Table 1
Evaluation of healthiness of food and drink pairs.

Pair	Healthy option		Unhealthy option	
	Item	Healthiness Rating	Item	Healthiness Rating
1	An apple	4.77	A cookie	1.68
2	A packet of baby carrots	4.71	A packet of crisps	1.70
3	Vegetable soup	4.43	A pizza	1.81
4	A salad	4.77	A burger	1.84
5	Baked fish with steamed vegetables	4.67	Fish and chips	1.92
6	A banana	4.62	A bowl of ice-cream	1.79
7	A sparkling water	4.10	A beer	1.86
8	A herbal tea	4.31	A caramel latte	1.70
9	A water with lemon	4.64	A cola	1.39
10	A carrot juice	4.49	A diet cola	2.11
11	A glass of milk	3.99	A hot chocolate	2.05
12	A still water	4.76	A lemonade	2.02
13	A tomato juice	4.28	A cocktail	1.89

Respondents were asked to choose between healthy – unhealthy options for all 13 pairs. The first two experimental groups saw only the items, i.e. they were asked to choose between, for example, an apple and a cookie (e.g. Choose between… *an apple* vs. *a cookie*). The third group was presented with the same items, alongside a reminder of the fact that each of these items had an effect on their health (e.g. Choose between… *an apple with its health effects* vs. *a cookie with its health effects*). The fourth group saw a reminder of consequences only for the unhealthy option (e.g. Choose between… *an apple* vs. *a cookie with its health effects*). Finally, the fifth group saw a reminder of consequences only for the healthy option (e.g. Choose between… *an apple with its health effects* vs. *a cookie*).

I wanted to distinguish between a possible effect of making consequences salient – which assumed that people knew about these consequences; they just didn't think of them when deciding – versus a possibility that a person may not have known that what she ate and drank had consequences on her health in the first place. To do so, I added an introduction, which informed people of the fact that what they eat and drink has consequences, including health ones. Specifically, the introduction read:

> Things we eat or drink, like those you will see in the following questions, can be thought of in many ways. For instance, how much do you enjoy consuming them? How much do they cost? Do they have effects on your health? And, if so, are these effects positive or negative?

All groups but Group 1 saw this introduction. Table 2 shows how choices were framed for each of the experimental groups using the example of an apple versus a cookie pair.

Table 2
Hidden Consequences study experimental groups and choice framing.

	Healthy option	**Unhealthy option**
Group 1 (No introduction)	An apple	A cookie
Group 2 (Introduction)	An apple	A cookie
Group 3 (Introduction)	An apple with its health effects	A cookie with its health effects
Group 4 (Introduction)	An apple	A cookie with its health effects
Group 5 (Introduction)	An apple with its health effects	A cookie

The choices were presented individually, one pair at a time. The order in which pairs were shown, as well as whether the healthy or the unhealthy option was shown first in a pair (on the left) were randomised.

Next, participants evaluated healthiness of all the items and likelihood to consume them. They, then, filled out a simplified version of the 14-item consideration of future consequences survey (CFC), which measures the extent to which people consider possible distant outcomes of their current behaviours and to which they are influenced by them (Joireman et al., 2012). Even though I did not explicitly state any time delay in the availability of the options, the impact of what we eat or drink on our health – such as a hang-over or a bigger waistline – is usually delayed. I, therefore, wanted to control for participants' concern with the future. Indeed, previous CFC research suggests that, relative to those scoring low on the scale, those scoring high on CFC scale are more likely to control their diet (Piko & Brassai, 2009), report a lower body mass index (Adams & Nettle, 2009; Adams & White, 2009) and exercise (Adams & Nettle, 2009; Ouellette, et al., 2005). I hence assumed that CFC would be a relevant variable in the context of health decision-making and this experiment.

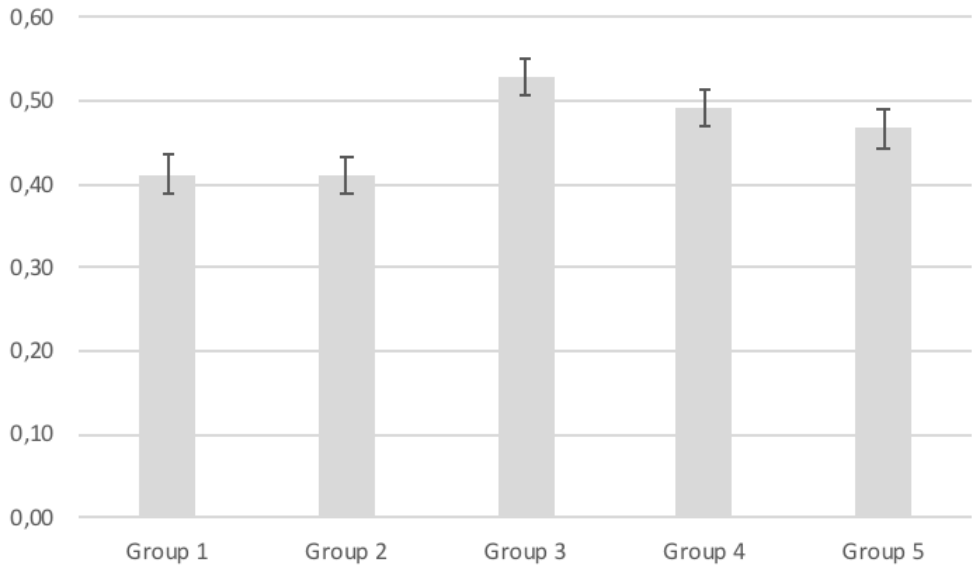
I simplified the language and sentence structure of the original CFC survey, using an online readability tool (Readability Formulas, n.d) so that the language was at grade six level (see Appendix A for a comparison of the original and simplified versions). Finally, participants provided demographic information.

Results

Respondents who were reminded that foods and drinks have health consequences were more likely to choose healthy options, no matter whether the consequences were mentioned for the healthy or the unhealthy items, corroborating the hypothesis. On average, people who were not reminded of any health consequences (Groups 1 and 2) chose the healthy items 41.99% (SD=19.98) and 41.76% (SD=24.34) of the time, respectively. People who saw consequences for both the healthy and unhealthy items (Group 3) chose the healthy items 52.94% (SD=22.46) of the time. Those who only saw health consequences for the unhealthy items (Group 4) chose the healthy items 49.06% (SD=20.69) of the time, whereas those who only saw consequences

for the healthy items (Group 5) chose the healthy items 46.79% (SD=18.32) of the time.

Figure 1
Hidden Consequences Study 1 group means with 95% confidence intervals.



This was confirmed by a multiple regression, using the number of healthy choices made (out of 13) as the dependent variable. The analysis showed two main effects for healthy (ß=.639, p=.049; 95% confidence intervals.037 to 1.275) and unhealthy (ß=.935, p=.004, 95% confidence intervals .303 to 1.567) consequences, with no interaction effect (ß=-.136, p=.783, 95% confidence intervals -1.104 to .832). Overall, the model explained 3.4% of variance (adjusted R^2=.034).

Table 3
Hidden Consequences Study 1 multiple regression.

Number of observations	550
$F_{(3,547)}$	7.40
Prob > F	0.000
R-squared	0.039
Adj R-squared	0.034
Root MSE	2.764

Source	SS	df	MS
Model	169.494	3	56.498
Residual	4178.372	547	7.639
Total	4347.866	550	7.905

	Coefficient	Std. Error	t	P>|t|	95% Confidence intervals	
Healthy consequences	.639	.323	1.98	0.049	.004	1.275
Unhealthy consequences	.935	.321	2.91	0.004	.303	1.567
Interaction	-.136	.493	-.28	0.783	-1.104	.832
Constant	5.443	.186	29.28	0.000	5.078	5.809

I repeated this analysis, removing all choices that included an item a person said they would not consume under any circumstances, in order to verify whether personal health conditions (such as allergies) or strong preferences did not skew the results. Removing these items had no significant impact on the results so subsequent analyses include all data.

The two main effects were significant for food pairs only, too. A multiple regression performed only on the six food pairs showed a main effect for healthy (ß=.461, p=.015, 95% confidence intervals .091 to .831) and unhealthy (ß=.468, p=.013, 95% confidence intervals .100 to .836) consequences and no interaction effect (ß=-.128, p=.656, 95% confidence intervals -.692 to .436). A multiple regression performed on the seven drink pairs showed a main effect for unhealthy consequences (ß=.467, p=.015, 95% confidence intervals .092 to .841). There was no significant effect for healthy consequences (ß=.178, p=.353, 95% confidence intervals -.198 to .555) nor an interaction effect (ß=.008, p=.979, 95% confidence intervals -.582 to .566).

Table 4
Hidden Consequences multiple regression for food pairs only.

Number of observations	551
$F_{(3,547)}$	6.72
Prob > F	0.000
R-squared	0.036
Adj R-squared	0.030
Root MSE	1.611

Source	SS	df	MS
Model	52.290	3	17.430
Residual	1419.424	547	2.595
Total	1471.713	550	2.676

	Coefficient	Std. Error	t	P>|t|	95% Confidence intervals	
Healthy consequences	.460	.189	2.44	0.015	.091	.831
Unhealthy consequences	.468	.187	2.50	0.013	.100	.836
Interaction	-.128	.287	-.45	0.656	-.692	.436
Constant	2.163	.108	19.96	0.000	1,950	2.376

Table 5
Hidden Consequences multiple regression for drink pairs only.

Number of observations	551
$F_{(3,547)}$	4.48
Prob > F	0.000
R-squared	0.024
Adj R-squared	0.019
Root MSE	1.639

Source	SS	df	MS
Model	36.116	3	12.038
Residual	1468.871	547	2.685
Total	1504.987	550	2.736

	Coefficient	Std. Error	t	P>|t|	95% Confidence intervals	
Healthy consequences	.178	.192	.93	.353	-.199	.555
Unhealthy consequences	.467	.191	2.45	.015	.093	.841
Interaction	-.008	.292	-.03	.979	-.582	.566
Constant	3.280	.110	29.76	.000	3.064	3.497

Multilevel regression.

Next, I conducted a multilevel binary regression (551 respondents X 13 choices), to control for the effect of individual differences on the likelihood of choosing healthy options. Again, I found two main effects of healthy and unhealthy consequences (healthy consequences ß=.194,

p=.020, 95% confidence intervals .030 to .358; unhealthy consequences ß=.294, p=0.000, 95% confidence intervals .129 to .458).

There was no significant effect of reminding people beforehand of the fact that what they ate had health consequences, i.e. the introduction (ß=.027, p=.807, 95% confidence intervals -.190 to .245). In other words, there was no significant difference in the likelihood to choose the healthy options between Groups 1 and 2, implying people *knew* what they chose to consume had an impact on their health, they just didn't think of the effect when making decisions.

Moreover, there was a significant effect of whether an item was a food or a drink, with respondents choosing the healthy options less often for food pairs (ß=-.404, p=.000, 95% confidence intervals -.505 to .304). There was no effect of the order in which pairs were shown. I expected the likelihood to choose the healthy option to increase as people kept making choices, making the intervention more salient the more times people saw it, yet this was not the case (ß=.004, p=.585, 95% confidence intervals -.009 to .017).

Next, I measured the effect of personal characteristics. Healthy lifestyle was measured on a 5-point scale, with higher scores meaning a healthier lifestyle, as self-reported by the respondents. Beta coefficient for a healthy lifestyle was ß=.317 (p=.000) with 95% confidence intervals between .233 and .400, implying that the healthier a person the more likely she was to choose healthy foods and drinks.

The second individual difference variable was a consideration for future consequences. This scale is composed of two subscales – one that assesses concern with future consequences (CFC-Future) and one that assesses concern with immediate consequences (CFC-Immediate). CFC was measured by reversing scores for the CFC-Immediate scale and summing up scores for all 14 questions, for a maximum of 70 points. The higher the score, the more future-oriented the person. Beta coefficient for CFC was ß=.010 (p=.023), with 95% confidence intervals between .001 and .020. These results suggest that the more future-oriented a person, the more likely she was to choose healthy options.

Finally, I measured the effect of several demographic variables. There was a significant effect of gender (ß=.414; p=.000, 95% confidence intervals

.260 to .568) and age (ß=.015, p=.000, 95% confidence intervals .008 to .021), with women and older people being more likely to choose healthy options. There was no effect of education level (ß=.041, p=.282, 95% confidence intervals -.034 to .117). The between-person (level 2) variance was estimated at .407, with 95% confidence intervals between .317 and .521.

Table 6
Hidden Consequences study multilevel regression.

Number of obs		7,136
Number of groups		549
Obs per group	Min	12
	Avg	13
	Max	13
Wald chi²(10)		219.24
Prob>chi²		0.000

Iteration points	7
Log likelihood	-4646.913

	Coefficient	**Std. Error**	**z**	**P>|z|**	**95% Confidence intervals**	
Healthy consequences	.194	.084	2.32	.020	.030	.358
Unhealthy consequences	.294	.084	3.50	.000	.129	.458
Introduction	.027	.111	0.24	.807	-.190	.245
Food	-.404	.051	-7.89	.000	-.505	-.304
Order of pairs	.004	.007	0.55	.585	-.010	.017
Gender	.414	.079	5.27	.000	.260	.568
Education	.041	.038	1.08	.282	-.034	.117
Age	.015	.003	4.38	.000	.008	.021
CFC	.010	.005	2.27	.023	.001	.120
Healthy lifestyle	.316	.042	7.45	.000	.233	.340
Constant	-2.785	.292	-9.55	.000	-3.357	-2.214

Random-effects Parameters	**Estimate**	**Std. Err**	**95% Confidence Intervals**	
Person	.407	.051	.317	.521

LR test vs. logistic model: chibar²(01) = 178.93; prob >= chibar² = 0.000

Single pairs regressions.

While, on the whole, the manipulation was effective, showing that mentioning health consequences made people more likely to choose a healthy snack, meal or drink, on their own few of the pair showed a significant effect. A series of multiple regressions showed a significant effect of both healthy and unhealthy consequences for *baked fish with steamed vegetable* vs. *fish and chips* pair (ß=-.092; p=.035; 95% confidence intervals .007 to .177 for unhealthy consequences; and ß=.100; p=.022; 95% confidence intervals .015 to .185 for healthy consequences). Two more pairs (*a water with lemon* vs. *a cola;* and *a still water* vs. *a lemonade*) showed a significant effect for unhealthy consequences (ß=.129 p=.003; 95% confidence intervals .045 to .213; and ß=.094; p=.023; 95% confidence intervals .013 to .175, respectively). Finally, one pair (*a banana* vs. *a bowl of ice-cream*) showed an effect for healthy consequences (ß=.097; p=.027; 95% confidence intervals .011 to .183). These results imply that the impact of the intervention may vary for different types of foods and drinks, suggesting the need to identify the characteristics of such items that make them better candidates for this type of a nudge, an issue discussed in more detail later in this chapter.

Table 7
Hidden Consequences study single pairs multiple regressions.

Pair	Type of consequences	ß	Std. Err	t	p	Confidence intervals	
An apple vs. a cookie	Healthy	.047	.044	1.06	.287	-.039	.133
	Unhealthy	.039	.044	0.88	.378	-.047	.124
Packet of baby carrots vs. Packet of crisps	Healthy	.042	.040	1.05	.040	-.037	.122
	Unhealthy	.055	.040	1.37	.040	-.024	.134
Vegetable soup vs. A pizza	Healthy	.055	.042	1.30	.194	-.028	.137
	Unhealthy	.075	.042	1.79	.073	-.007	.158
A salad vs. A burger	Healthy	.065	.044	1.48	.139	-.021	.151
	Unhealthy	.075	.044	1.71	.089	-.011	.161
Baked fish with veg vs. Fish and chips	Healthy	.100	.043	2.30	.022	.015	.185
	Unhealthy	.092	.043	2.30	.035	.007	.177
	Healthy	.097	.044	2.22	.027	.011	.183

A banana vs. A bowl ice-cream	Unhealthy	.078	.044	1.79	.075	-.008	.164
A sparkling water vs. A beer	Healthy	-.010	.044	-0.23	.815	-.096	.076
	Unhealthy	.052	.044	1.19	.234	-.034	.138
An herbal tea vs. A caramel latte	Healthy	.038	.044	0.87	.385	-.048	.124
	Unhealthy	.036	.044	0.83	.404	-.049	.122
A water with lemon vs. A cola	Healthy	.032	.043	0.74	.461	-.053	.116
	Unhealthy	.129	.043	0.74	.003	.045	.213
A carrot juice vs. A diet cola	Healthy	.018	.043	0.41	.685	-.067	.102
	Unhealthy	.029	.043	0.66	.508	-.056	.113
A glass of milk vs. A hot chocolate	Healthy	.027	.044	0.62	.536	-.059	.113
	Unhealthy	.083	.044	1.90	.059	-.003	.168
A still water vs. A lemonade	Healthy	.025	.041	0.60	.552	-.057	.106
	Unhealthy	.094	.041	2.28	.023	.013	.175
A tomato juice vs. A cocktail	Healthy	.046	.040	1.15	.250	-.033	.125
	Unhealthy	.041	.040	1.02	.309	-.038	.120

Study 2

In the second study, I set out to verify whether the same effect would hold for real, rather than hypothetical, choices, i.e. if people were actually going to receive (and eat) the snacks they choose. It must be noted that this lack of effect for individual pairs in Study 1 made this simple field experiment an opportunistic study. Yet, I have decided to proceed with it, to test the impact of this nudge in an even more real-world context and assuming the effect of the manipulation would be stronger when people made real choices.

Due to practical constraints, few of the pairs chosen for Study 1 could be used in Study 2. I decided to offer people a choice similar to the first pair (*an apple* vs. *a cookie*) since the products could be easily carried, handed out and consumed. I decided to broaden the choice, to ensure the snacks were attractive enough to study participants. Taking all this into consideration, participants in this study were offered a choice between a piece of fruit (a green apple, a red apple, a banana) and a packet of cookies (a single serving packet of classic Oreos or Maryland chocolate chip cookies).

Methods

Participants.

Three hundred seventy-seven people took part in the experiment, a sample size exceeding a minimum size based on a power analysis conducted after Study 1. Most participants were university students, with some staff and faculty, as well as a few students' parents and university guests. Since the aim of this study was to corroborate the results of the online experiment, it was a simple, one-question study and I did not record information on gender, age or any other demographic data.

Procedure.

The experiment was conducted at Warwick Business School (WBS) over the course of three days in June of 2017. Participants were recruited in two locations, both in the main WBS building. Eighty-one people were approached by one of three experimenters outside the behavioural science laboratory, while they waited for another experiment to start. They were handed one sheet of paper (see Appendix B), were asked to carefully read instructions and to answer a question on that sheet. There were five experimental groups and the sheets were printed in order, meaning that every fifth person was allocated to the same condition. The order of the answers was *not* randomised, with the healthy option (*a piece of fruit*) always shown as the first choice (on top).

Once participants made their choices, they were given tokens – a yellow one if they chose a piece of fruit, a red one if they chose a packet of cookies. At this point they did not get the actual snacks. Once they finished another experiment (about an hour later), they were greeted again, in the same location outside the laboratory, by an experimenter. They were asked to hand back their tokens and to pick, from a table, the snacks they had previously selected. If a person had a yellow token, they could choose a green apple, a red apple or a banana. If they had a red token, they could choose a packet of Oreos or Maryland chocolate chip cookies.

Since the experiment was conducted at the end of a summer term, during exam period and with few experiments happening at the laboratory, I was unable to recruit enough people for the study in this location. Therefore, the remaining 296 participants were recruited in a hall outside of a university cafeteria. Passers-by were greeted by one of the experimenters and were asked if they would agree to participate in a short study. If they agreed, they were given a sheet of paper with instructions and the question. Just like outside the laboratory, the five conditions (versions/frames of the question) were ordered one by one, meaning that every fifth person was allocated to the same experimental group. If people came in groups, they were explicitly asked to only read their sheet and the researcher made sure people stood apart so that they couldn't read a friend's version.

Once participants made their choices, the experimenter took their answer sheets and showed them a bag, set on the side, from which they could choose a snack. The same types of fruit and cookies were offered as outside the laboratory. Participants were not allowed to change their minds after handing back the answer sheets and were only allowed to choose from the three types of fruit, if they chose a piece of fruit, or from the two types of cookies if they chose a packet of cookies.

Results

On average, people in Groups 1 and 2, who saw choices without any mention of health consequences, chose the healthy item 65.22% (SD=47.98) and 55.56% (SD=50.00) of the time, respectively. Participants in Group 3, who were reminded of both healthy and unhealthy consequences, chose the healthy option 68.83% of the time (SD=46.62). Participants in Group 4, who were reminded of healthy consequences only, and Group 5, who were reminded of unhealthy consequences only, chose the healthy option 64.86% (SD=48.07) and 63.16% of the time (SD=48.56), respectively.

I conducted a multiple regression with two main effects of healthy consequences (ß=.032; p=.643; 95% confidence intervals -.102 to .165) and unhealthy consequences (ß=.057; p=.468; 95% confidence intervals -.097 to .210), as well as an interaction effect (ß=-.008; p=.938; 95% confidence

intervals -.213 to .196). There were no significant differences between any of the groups.

Figure 2
Hidden Consequences Study 2 group averages with confidence intervals.

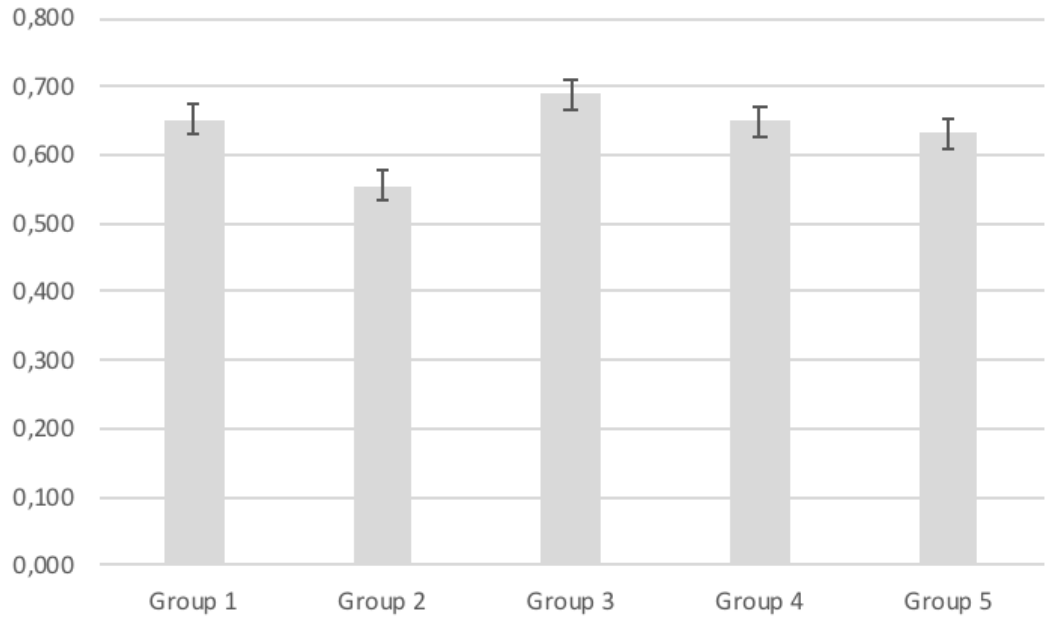


Table 8
Hidden Consequences Study 2 multiple regression.

Number of observations	377
$F_{(3,373)}$	0.60
Prob > F	0.618
R-squared	0.005
Adj R-squared	0.003
Root MSE	.483

Source	SS	df	MS
Model	.417	3	.139
Residual	87.069	373	.233
Total	87.485	376	.233

	Coefficient	Std. Error	t	P>|t|	95% Confidence intervals	
Healthy consequences	.032	068	0.46	0.643	-.102	.165
Unhealthy consequences	.057	.078	0.73	0.468	-.097	.210
Interaction	-.008	.104	-0.08	0.938	-.213	.196
Constant	.600	.039	15.21	0.000	.522	.678

Discussion

In this study, I set out to verify whether people could be nudged to choose healthier foods and drinks by a simple reminder that what they consume has an effect on their health. Specifically, I hypothesised that reminding people of health consequences of healthy and/or unhealthy options would make them more likely to choose a healthier snack, meal or drink. Support for this hypothesis is arguable.

Results of Study 1 showed that those who were reminded of the fact that foods and drinks had an effect on their health were more likely to choose healthy options, regardless of whether these consequences were mentioned for healthy or unhealthy items. On average, people who were not reminded of health consequences (Groups 1 and 2) chose the healthy items 41.87% of the time (SD=22.25). People who saw consequences for either the healthy or unhealthy items, or both (Groups 3, 4 and 5), chose the healthy items 49.60% of the time (SD=20.66).

As hypothesized, people who scored higher on consideration of future consequences scale were more likely to choose the healthy options. Indeed, previous research indicates a correlation between concern with the future (time discounting) and health behaviours. People who are more likely to engage in unhealthy behaviours, such as overeating or binge eating (Kulendran et al., 2013; Weller et al., 2008), not exercising (Chabris et al., 2008; Daughtery & Brase, 2010), smoking (Bickel et al., 1999; Fields et al., 2009; Mitchell, 1999; Odum, Madden & Bickel, 2002; Reynolds, 2006; Reynolds et al., 2003; 2004; 2007a; 2007b; 2009; Rezfarnard et al., 2010; Stilwell & Turney, 2012; Wing et al., 2012) or drinking alcohol (Mackillop et al., 2011) tend to discount the future more.

However, I was unable to replicate the effect in Study 2. Neither the

mention of the effect of healthy or unhealthy items on one's health had a significant impact on which snack – a piece of fruit or a packet of cookies – people chose. On average, those who were not reminded of health consequences (Groups 1 and 2) chose the healthy option 60.00% of the time (SD=49.15), while those who were reminded of health consequences (Groups 3, 4 and 5) chose it 65.64% of the time (SD=47.60).

There are several reasons that can explain such results. First and foremost, Study 2 was an opportunistic study. The food items chosen for the study were based on one of the pairs used in Study 1 (*an apple* vs. *a cookie*), despite the fact that there was no significant effect of the manipulation for this pair alone. A regression conducted on the *apple* vs. *cookie* pair showed two null effects of healthy (β=.047; p=.287; 95% confidence intervals -.039to .133) and unhealthy (β=.039; p=.378; 95% confidence intervals -.047 to .124) consequences. My assumption that the manipulation would have a stronger impact when people made real choices, which justified the decision to conduct this simple field experiment, was wrong.

Moreover, there was a substantial amount of noise associated with the set-up of the study. As the experiment was conducted in the halls of a university, many participants were on their way somewhere. While everyone was asked to carefully read the instructions and what choices were offered (how they were framed), there is no guarantee all respondents have done so. Indeed, feedback received from the experimenters after the study suggested that some of the participants just looked at the available snacks and immediately made a choice, without paying much attention to the instructions and choice framing.

Thirdly, a significant proportion of WBS students are not from the UK and therefore English is not their native language; and as research indicates, language-based interventions, such as the one used in these experiments, have a stronger effect when delivered in a person's native language (Keysar, Hayakawa & An, 2012). Although I did not record the participants' native languages, overall approximately 30% of WBS students[1] are international

[1] Since data regarding the proportion of British vs. international students attending all programmes at the Warwick Business School is not monitored by one entity but rather, each department does, or does not, monitor this information for its own cohorts, I was unable to obtain the exact number of local vs. foreign students.

students. Assuming a similar proportion of Study 2 participants were also non-native speakers, it could be another reason why the manipulation had less of an impact.

I believe that despite the null results of Study 2 and the fact that few individual pairs in Study 1 showed a significant effect, the concept of consequence salience in communication is a viable one and should be explored further, especially considering the fact that I was able to detect an effect in Study 1 (albeit a small one), as well as the robustness of previous studies that looked into consequence salience, referenced earlier in this chapter. The simplicity of this of communication-based nudge is an important advantage, which could make it yet another easy-to-implement and effective behavioural change technique.

However, before this approach can be effectively used in the field, we need a better understanding of when, where and how exactly to use it. Specifically, we need to be able to answer the following questions:

- What products are likely to be influenced by the intervention and what type of consequences should be communicated?
- How do personal characteristics influence the effectiveness of this nudge?
- When and where is it best to deliver such an intervention?
- What is the best context in which such an intervention should be used?

What. We need to identify for what type of foods and drinks people's choices are more likely to be influenced. As the analysis conducted in Study 1 showed (see Table 7 on pages 37-38) the effect of framing differed for individual pairs. It could be that there are certain characteristics of foods and drinks that make some of our consumption choices more prone to influence than others. A subsequent study should focus on identifying these characteristics and evaluating the impact of the intervention on different types of consumption goods. This, in turn, would make it possible to know what types of foods and drinks should be considered when using this type of nudge in the real world.

Secondly, it is important to identify what type of opportunity costs should be highlighted in communication and how to frame these consequences to maximise their salience and, subsequently, the impact of an intervention. I chose to communicate health effects but it may be the case that different types of opportunity costs, of the various mentioned at the beginning of this chapter, would have a greater impact.

Who. As the results of Study 2 suggest, it is possible that factors such as knowledge of the language in which an intervention is delivered and the state in which a person encounters the intervention (e.g. being in a hurry, hunger) had a significant impact on the effectiveness of the intervention. These, and many other, factors may become unnecessary barriers, preventing the message from effectively reaching the target audience. Future research should focus on identifying the impact of such individual differences, which would, in turn, help identify the qualities a group of people should have in order for an intervention to effectively promote healthy eating.

When, where and how. All the person-related factors are closely linked to the location, timing and mode of delivery of an intervention. For a behavioural change technique to work in the field, it needs to be delivered in a right place, at a right time and in the right way. Ideally, the intervention should reach its target audience at the time of decision-making and in a place that allows for it to be seen. Yet, 71.35% of Study 2 participants were recruited in a university hall, by an exit and a cafeteria. This location meant that people were often in a hurry, or simply not thinking of food as they were on their way somewhere, have just eaten or, conversely, were hungry and wanted to eat something substantial rather than a small snack.

Moreover, quite obviously, handing out sheets of paper with an offer of a free snack isn't the most natural way in which people get food. Subsequently, neither is it a setting in which people are receptive to such messages. This factor could explain why the manipulation didn't result in the expected behaviour change. Future research should consider how the location, timing and mode of delivery impact intervention effectiveness, with the aim of identifying circumstances that yield the greatest improvement in

eating choices. I believe that nudge could be very effective if tested and applied in situations where people actually make food choices, e.g. on restaurant menus, food labels in stores or in product descriptions in online stores.

Conclusions

While more research is clearly needed before nudges based on consequence salience can be effectively used to improve choices in the real world – health or otherwise – the work described in this chapter is a step towards developing such an approach. It describes two research studies that attempted to use this nudge in a real-world context and outlines directions for future research.

Additionally, a more general aim of this study was to showcase how one could approach the development of new behavioural change techniques, to broaden the pool of available tools that can be used in communication to influence cooperation in social and intrapersonal dilemmas. As the subsequent chapters will show, there are close to 100 different behavioural change techniques currently being used in behavioural change research, yet the majority of them have *not* been developed with communication in mind, making the actual list of available tools much shorter. At the same time, there are many insights readily available in already-published work, *hidden zero effect* being one of them. These insights could be developed, to eventually become impactful yet simple behavioural change techniques, readily available to be used by those who want to help people make better choices but who don't have influence over policy or resources to use more elaborate or legislation-based approaches.

CHAPTER THREE

#LetsUnlitterUK: A behavioural change intervention to encourage people to post anti-littering messages on Twitter

Introduction

Behavioural change interventions have proven to be an effective tool to tackle some of the most important social issues (see e.g. Behavioural Insights Team 2016b; 2017). What distinguishes this approach from others, such as social marketing, for example, is that it is based on theory and evidence. Indeed, research indicates that interventions rooted in theory and evidence, as opposed to those relying simply on intuition, are more effective in changing people's behaviours (Abraham et al., 2009; Albarracin et al., 2005; Noar & Zimmerman, 2005; Webb et al., 2010). As Cane, O'Connor and Michie (2012) suggest, the latter can lack a thorough understanding of a problem at the root of an undesired behaviour.

Designing effective interventions requires one to understand a behavioural problem comprehensively, through the lens of one or several relevant theories (Francis, O'Connor & Curran, 2012). Yet the number of these theories is vast. Recently, Michie et al. (2014b) compiled a guide, in which they listed 83 theories, related to health decision-making only. This plethora of choice can make it difficult for researchers and choice architects to select the most appropriate approach, on which an intervention should be based; and once a choice is made, the risk of important aspects of a problem being omitted remains, if no systematic approach is selected (Francis, O'Connor & Curran, 2012). This may explain why, despite the recommendation to use theory when developing complex interventions (Craig et al., 2008), many are still developed without a theoretical basis or do not consider existing evidence (Michie, et al., 2014b).

In addressing this need for simple, practical and theory-driven tools for designing interventions, multiple frameworks have been developed, with some well-known ones such as Behavioural Insights Team's EAST (Behavioural Insights Team, 2014b) and MINDSPACE (Dolan et al., 2010. Yet probably the most comprehensive of these frameworks is the Behavioural Change Wheel (Michie, Atkins & West, 2014a), which condenses theoretical ideas described in 19 other frameworks into one practical tool.

The BCW was developed with medical personnel and patient safety in mind (Michie et al., 2005), yet, at the same time, its aim has been to enhance

the usefulness of behavioural theory to researchers from a range of disciplines (Francis, O'Connor & Curran, 2012). The first objective of this study was to apply this framework to environmental decision-making, in order to evaluate its effectiveness in this different, non-medical context. The second aim was to develop and test a new, simple way of measuring behavioural change – through a Qualtrics – Twitter interface – which could be used by other researchers and choice architects to evaluate the impact of their interventions and which would not require the setting up of a field experiment (which can often be difficult and time-consuming). These two objectives address the two distinguishing features of behavioural change approach – by following the BCW, I rooted my interventions in theory and was able to evaluate the effectiveness of such approach; and by measuring the impact of the interventions on three different dependent variables, I ensured that the evaluation was based on evidence.

This chapter starts with an outline of the Behavioural Change Wheel. I briefly explain BCW steps and provide an overview of published literature addressing each one. Next, I explain the problem and ways of measuring impact in behavioural research and describe the new dependent variable measure (Qualtrics – Twitter interface) used in my experiment. Finally, I describe the methodology of the study, present results and discuss their implications.

The Behavioural Change Wheel

Step 1: Identification of behavioural barriers and enablers.

The first step of the BCW is to identify barriers to and enablers of a desired (target) behaviour. The BCW outlines three such potential mediators – capability, opportunity and motivation – and offers a diagnostic tool, called the theoretical domains framework (TDF; Cane, O'Connor & Michie, 2012; Michie et al., 2005) that can be used to identify them. TDF consolidates explanatory constructs from 33 theories and groups them into 14 theoretical construct domains, providing a comprehensive set of potential mediators of behavioural change (Cane, O'Connor & Michie, 2012; Michie

et al., 2005). Each domain consists of several theoretical constructs (component parts of theories), e.g. the *social influences* domain consists of group norms, group conformity, social pressure, social comparisons and social support (Michie et al., 2005). TDF can be used both in the form of a questionnaire (see Huijg et al., 2014) or as a template for interpreting qualitative data (e.g. in-depth or focus group interviews).

I conducted a literature search, to find published studies that used the TDF in the form of a questionnaire (as opposed to with qualitative data). I were able to find 12 such publications (by searching for articles, on Scopus, which reference the original TDF paper [Michie et al., 2005] and had the keywords "theoretical domains framework" and "questionnaire" or "quantitative" in title, abstract or as a keyword), therefore finding evidence that the TDF has been effectively used in the form of a questionnaire to identify mediators of behaviours such as implementation of health-related guidelines (Bonetti et al., 2014; Manikam et al., 2015; McParlin et al., 2017; Seward et al., 2017; Taylor et al., 2013) and new diagnostic tools (Gnich et al., 2015; Huijg et al., 2015; Skoien et al., 2016) among medical staff, encouraging patient medical testing (Auld & Johnston, 2016), medication adherence (Voshaar et al., 2016) and healthy lifestyle (Amemori et al., 2013; Taylor, Lawton & Conner, 2013).

Step 2: Intervention development.

Once a behavioural diagnosis is in place, the second step of the BCW is to select an intervention function (education, persuasion, incentivisation, coercion, training, restriction, environmental restructuring, modelling, enablement) that will help address the relevant barriers, and then to select policy categories (*Communication/Marketing, Guidelines, Fiscal measures, Regulation, Legislation, Environmental/Social planning, Service provision*) that can support the delivery of the intervention function. Next, one needs to select one or several of the 93 behavioural change techniques (Michie et al., 2008; Michie et al., 2013), on which an intervention is build.

This approach to intervention development has been used in many studies to guide researchers in the process of intervention development,

in areas such as patient safety (Ayakaka et al., 2017; Cadogan et al., 2015; Cadogan et al., 2016; Clark et al., 2017; Fleming et al., 2014; Mc Sharry et al., 2016; Murphy et al., 2017; Steinmo et al., 2015; Steinmo et al., 2016; Templeton et al., 2016), medication adherence (Barker et al., 2016; McCullough et al., 2015; Timmerman, Stronks & Huygen, 2017) and improving health of different social groups, e.g. by encouraging pregnant women to quit smoking (Gould et al., 2017; Tombor et al., 2016), promoting healthy eating (Smith et al., 2016), physical activity (Connell et al., 2015; Westland et al., 2017), hygiene (Suntornsut et al., 2016) and condom use among men (Webster et al., 2015).

To my knowledge, there are only four studies in which the BCW has been used to support the development or evaluation of non-health related interventions. Staddon et al. (2016) used the BCW approach to review and synthesize empirical evidence to identify the types of behaviour change interventions that would be most successful at promoting energy-saving in the workplace. Wilson and Marselle (2016) used the BCW to organize and map out components of four EU guidance documents relating to energy conservation. Wells et al. (2016) used the framework to design a game with the purpose of promoting energy conservation and, finally, Gainforth et al., (2016) used the framework to develop a recycling intervention.

Step 3: Evaluation.

The final step of the BCW is to implement an intervention and to measure its impact. There are only two publications I am aware of, in which the BCW approach to intervention design has been used *and* that provide information on the effectiveness of such interventions (rather than only describing their content/BCTs used). Webb et al. (2016) delivered an intervention aimed at encouraging nurses to provide brief advice on the benefits of physical activity to cancer patients. They were able to improve the rate of delivery, as measured after 12 weeks ($Z=-4.39$, $p<0.01$). Curtis et al. (2017) set out to design an intervention targeting the update of a chest injury protocol among medical staff. They were able to increase the uptake by approximately 25%, from 68.4% to 91%.

Measuring Impact

Impact measurement is the second of the two aforementioned distinguishing features of behavioural change approach. A good intervention needs not only to be rooted in theory but also its effect needs to be evaluated. This commitment to measuring impact lets choice architects know if, and to what extent, an intervention (and/or the BCTs it is composed of) was successful in a given context.

There are several commonly used approaches to testing this. The first one is to set up a randomised control trial (RCT) and to measure changes in the dependent variable (target behaviour) between experimental groups that underwent different interventions and a control group. Since RCTs are typically conducted in the same location, context, on the same group and measure impact directly, they are considered the most reliable approach (Behavioural Insights Team, 2014a). Yet it is also an approach that may require the biggest amount of resources – financial, time, human or otherwise – to plan, prepare and implement, making it generally a complex, rather than simple, approach.

Moreover, some behaviours can be difficult to measure, even if there were resources to set up an RCT.

One example of such behaviour, of particular interest here, is littering. In the UK, litter is collected by local councils, from both bins (items that have been properly disposed of) and from the ground (items that have been improperly disposed of). Once collected, both these types of litter are often put in the same container and taken to a dump site (DEFRA, 2013). Therefore, unless one was to engage a local council in an intervention and to modify the procedure of collecting litter, it may be impossible to know whether an intervention had a significant impact on the amount of litter properly, as opposed to improperly, disposed of. Even if one was able to engage a local council, there would be no guarantee of success, as measurement requires precision, which, depending on the details of how the litter-picking process is designed and how an intervention is set up (e.g. the type of litter being measured; durability of that litter; its size; precision of

litter-picking team in measuring/counting litter, etc.), may be difficult to deliver.

An alternative solution to estimating the impact of an intervention would be to measure its effect on people's intent (e.g. to not litter), rather than actual behaviour. Indeed, there are several theories, including the commonly used theory of planned behaviour (Ajzen, 1985, 1991; Ajzen & Madden, 1986; Noar & Zimmerman, 2005), theory of reasoned action (Fischbein, 1980; Fishbein & Ajzen, 1975) or the model of interpersonal behaviour (Triandis, 1977, 1980) that suggest intentions have a key role in predicting behaviour. Since intent can be easily measured, even with a one-question survey, it is an attractive alternative to setting up a field study – one can test several interventions,
ask people about their intent to perform a target behaviour and, based on the answers, choose the one intervention to be implemented in the field that will yield the greatest change in intent (and, subsequently, in behaviour). One issue with this approach, however, is that the correlation between intent and behaviour can be low (Webb & Sheeran, 2006).

To address this issue, I used three dependent variable measures to evaluate the impact of my interventions. The first dependent variable was intent, i.e. a one-question measure of how likely a respondent was to perform a behaviour – tweeting an anti-littering message – in the future. The reason I chose tweeting anti-littering messages as the target behaviour, rather than actual littering behaviour, relates to the second dependent variable measure, and an innovative aspect of this study. The second dependent variable measure was message quality. I conducted a short follow-up study in which participants were asked to rate the quality of Twitter messages written in the main study.

Finally, the last measure was a Qualtrics – Twitter interface. This tool was developed with the aim of addressing the problem of impact measurement and, subsequently, outlining one way through which behavioural change interventions could be simplified. Rather than targeting littering directly, I chose to address a "proxy" behaviour – actively raising the issue on social media. Specifically, study participants were asked to write and then post, on their personal Twitter accounts, anti-littering messages. Since

the message was to include a unique hashtag, I was able to monitor how many people posted their tweets. By matching the publicly posted tweets with study data from the (Qualtrics) dataset, I was able to estimate the impact of different interventions on behaviour.

Obviously, posting about an issue on social media is not the same as actually performing a behaviour. However, a couple reasons warrant such an approach. First, the two main objectives of this study were to (1) find a simpler way of delivering and measuring the impact of an intervention; and (2) to test whether the BCW can be effectively used in the context of environmental decision-making. With these two goals in mind, the approach of choosing a "proxy" behaviour and being able to instantly evaluate the effect of several different interventions, justifies the steps taken. Second, with so much academic research taking place and social media being such a ubiquitous part of our lives these days, merging the two seemed like a natural step towards simplifying and enhancing academic research.

Methodology

I conducted two research projects, each composed of several online experiments/surveys. The goal of both these projects was (1) to identify key behavioural change barriers/enablers of a chosen (target) behaviour and then, based on the diagnosis, to (2) develop a behavioural change intervention, following the BCW framework, to evaluate its effectiveness. The rest of the methodology and the results sections of this chapter follow the Behavioural Change Wheel framework. Table 9 outlines the design of the study and provides an overview of subsequent chapter sections.

The first step of both the research projects was to identify the target behaviour. To do so, I designed a survey, based on the theoretical domains framework, to identify key mediators of (not) posting anti-littering messages on Twitter (Step 2), and conducted the survey (Study 1.1). Next, I followed the steps outlined in the BCW to identify the best behavioural change techniques to use in the intervention (Steps 3 to 7) that would address key behavioural barriers/enablers. I then designed and tested several interventions (Step 8/Study 1.2), aimed at increasing intent to tweet

anti-littering messages. Finally, I evaluated the effectiveness of these interventions (Step 9). The same procedure was applied in Study 2. See Table 9 for an outline of all the steps.

Table 9
Twitter study project/BCW steps.

		Step	Description
	1	Problem definition	Define the problem in behavioural terms; select and specify the target behaviour
Study 1	2	Theoretical domains framework	Develop a list of statements relating to 14 domains
	3	Key domains (Study 1.1)	Identify key behavioural mediators of the selected target behaviour
	4	Identify intervention functions	Match the identified domains with the BCW interventions functions
	5	Identify policy domains	Match interventions functions with policy domains
	6	Identify BCTs	Select and develop BCTs to be used in the intervention
	7	Identify mode of delivery	Select mode of delivery for the chosen BCTs
	8	Intervention (Study 1.2)	Conduct the intervention (main experiment)
	9	Message evaluation (Study 1.3)	Evaluate the quality of tweets written by Study 1.2 participants
	10	Evaluation	Evaluate the effectiveness of the interventions
Study 2	11	Key domains (Study 2.1)	Identify key behavioural mediators of the selected target behaviour
	12	Identify intervention functions	Match the identified domains with the BCW interventions functions
	13	Identify policy domains	Match interventions functions with policy domains
	14	Identify BCTs	Select and develop BCTs to be used in the intervention
	15	Identify mode of delivery	Select mode of delivery for the chosen BCTs
	16	Intervention (Study 2.2)	Conduct the intervention (main experiment)

17	Evaluation	Evaluate the effectiveness of the intervention

Study 1

Step 1: Problem Definition

The first step of the Behavioural Change Wheel approach is to define the problem in behavioural terms and to select and specify the target behaviour. The behaviour was defined as follows:

- Who needs to perform the behaviour? *Participants of the study, which will be conducted via Prolific Academic; only people who live in the UK and have a Twitter account will take part in the study.*
- What do they need to do differently to achieve the desired change? *They need to write an anti-littering message when prompted to do so in the study, with a given hashtag (#LetsUnlitterUK, #DelitterUK, #DelitterGB, #NolitterUK, #NolitterGB, #UnlitterUK) and to click on a button to Tweet the message through their Twitter account.*
- When do they need to do it? *At the end of the study, when prompted to do so.*
- Where do they need to do it? *Online, on Twitter.*
- How often do they need to do it? *Once.*
- With whom do they need to do it? *Alone.*

Step 2: The Theoretical Domains Framework

Development of the TDF statements.

To identify factors meditating intent to tweet anti-littering messages, I developed a questionnaire based on the theoretical domains framework. The TDF is composed of 14 domains: *Knowledge; Skills; Memory, attention and decision processes; Behavioural regulation; Social/professional role*

and identity; Beliefs about capabilities; Optimism; Beliefs about consequences; Goals; Reinforcement; and *Intentions*. Based on statements outlined for each of the 14 domains in Huijg et al., (2014), I drafted a survey aimed at identifying motivational barriers to not tweeting anti-littering messages. Each domain was composed of one to three statements, as shown in Table 1 in Appendix C.

Step 3: Identifying Key Domains (Study 1.1)

Participants.

Participants were recruited through Prolific Academic, an online platform where people can earn money by participating in online research. I restricted the sample to UK residents who had a Twitter account, based on information provided in a person's Prolific Academic profile. Two hundred twenty-two respondents took part in this experiment. However, since 25 of them claimed to not use Twitter when asked at the beginning of the survey, they were excluded from the study. Overall, 197 respondents filled out the survey (mean age=31.04; 34.5% female). Participants were paid £0.75.

Procedure.

First, participants were asked to evaluate how big of a problem they thought litter was in the UK. They marked their answers on a scale from 1 (strongly disagree) to 7 (strongly agree). Next, they were told they were going to see and be asked to evaluate statements about how and why people may use Twitter to raise awareness of the problem of litter, by tweeting anti-littering messages. They were provided with a definition of what was meant by "anti-littering messages". Specifically, they read that this was referring to:

- Writing posts encouraging others to not litter, or to clean up litter;
- Posting pictures of places with litter, encouraging local councils to clean it up;
- Posting pictures of litterers and fly-tippers;
- Writing posts about the negative consequences of litter.

Next, they were shown, in a random order, the 30 TDF statements and were asked to evaluate how much they agreed with them, on a 7-point scale. Then, they were asked how often they used and posted on Twitter and were requested to write a Twitter message, no longer than 140 characters, about litter. They were provided with and requested to use a unique hashtag (#LetsUnlitterUK) in their messages. I chose a hashtag that had not been used on Twitter before this study, which allowed me to track messages that the respondents posted, and to match these messages with data from my dataset.

In the next step, participants provided demographic data. Finally, they were given the opportunity to actually tweet the anti-littering message they had written earlier. They were shown their messages and were told that if they wanted, they could post them on Twitter by clicking on a button. At the bottom of the page, there was a *Tweet* button, which opened a Twitter pop-up window, in which the person's message appeared. By clicking a *Tweet* button in the pop-up window, participants were able to post their messages onto their Twitter accounts (if a person was not logged into her account she saw a *Log in and Tweet* button and the steps were the same, once she provided her login and password).

TDF results.

I first performed Cronbach Alpha analysis to measure the internal consistency of the 14 TDF scales. Most of the domains were composed of only two statements. Two domains (*Goals* and *Optimism*) were one-question scales, and five domains (*Goals; Reinforcement; Memory, attention and decision processes; Knowledge*) were composed of three statements. For each domain that had three statements, I removed an item, based on the results of the analysis, to increase internal consistency of the scale. Items that were removed in the analysis are marked with an asterisk in Table 1 in Appendix C. All subsequent analyses are based on this shorter version of the TDF.

Overall, four scales (*Knowledge, Social/professional role and identity, Goals, Beliefs about consequences*) had a Cronbach's Alpha of 0.7 or higher, whereas for eight (*Cognitive and interpersonal skills; Memory, attention and decision processes; Social influences; Beliefs about capabilities; Reinforcement; Behavioural regulation; Emotion; Environmental context and resources*) Alpha was lower. These lower scores seemed justified considering the statements within each domain related to diverse areas of a person's life/behaviours, i.e. they were not homogeneous. As there was a need to keep the survey short (under 10 minutes) and, most importantly, the statements were based on a previously validated list (see Huijg et al., 2014), I concluded the data to be reliable and I proceeded to design interventions based on the results.

Table 10
Cronbach's Alphas for Twitter Study 1.1 domains.

Domain	Number of statements	Cronbach's Alpha	Alpha after item removed
Knowledge	3	.554	.731
Cognitive and interpersonal skills	2	.679	-
Memory, attention and decision processes	3	.244	.670
Behavioural regulation	2	.506	-
Social influences	2	.692	-
Environmental context and resources	2	.099	-
Social/professional role and identity	2	.762	-
Beliefs about capabilities	2	.642	-
Optimism	1	-	-
Intention	1	-	-
Goals	3	.556	.742
Beliefs about consequences	2	.756	-
Reinforcement	3	.454	.600
Emotion	2	.448	-

I conducted a multiple regression, using the *Intention* scale as a dependent variable. The model was significant ($F_{(13,184)}=48.091$; p=.000), with an adjusted R^2 of .757. Five domains were identified as significant predictors of intention to tweet – *Social/professional role and identity* (β=.276; p=.002; 95% confidence intervals .107 to .446); *Memory, attention and decision processes* (β=-.159; p=.021; 95% confidence intervals -.293 to -.024); *Goals* (β=.315; p=.000; 95% confidence intervals .140 to .489)

Optimism (β=.206; p=.008; 95% confidence intervals .056 to .357); and *Behavioural regulation* (β=.323; p=.001; 95% confidence intervals .128 to .519).

Table 11
Twitter Study 1.1 multiple regression.

Number of observations	198
$F_{(8,189)}$	48.091
Prob > F	.000
R-squared	.773
Adj R-squared	.757

Source	SS	df	MS
Model	659.418	13	50.724
Residual	194.077	184	1.055
Total	853.495	197	

	Coefficient	Std. Error	t	P>|t|	95% Confidence intervals	
Knowledge	-.041	.120	-.336	.737	-.278	.197
Skills	-.175	.099	-1.774	.078	-.370	.020
Social/prof role and identity	.276	.086	3.213	.002	.107	.446
Beliefs about Capabilities	-.029	.086	-.339	.735	-.198	.140
Optimism	.206	.076	2.701	.008	.056	.356
Beliefs about Consequences	-.054	.103	-.520	.603	-.256	.149
Reinforcement	-.106	.111	-.958	.339	-.324	.112
Goals	.315	.088	3.562	.000	.140	.489
Memory, attention & decision proc	-.159	.068	-2.323	.021	-.293	-.024
Environment	-.005	.079	-.061	.952	-.161	.152
Social influences	.177	.090	1.957	.052	-.001	.355
Emotion	.165	.084	1.961	.051	-.001	.331
Behavioural regulation	.323	.100	3.243	.001	.126	.519
Constant	.315	.840	.376	.708	-1.342	1.973

Step 4: Identifying Intervention Functions

The next step in the BCW is to link such a behavioural diagnosis with functions that an intervention can serve. The BCW lists nine such functions – education, persuasion, incentivisation, coercion, training, restriction, modelling and enablement – and links them to TDF domains. Together,

the five domains identified in Step 3 linked to all intervention functions listed in the BCW. Therefore, in Step 4, I did not eliminate any other domains. I knew, however, that due to the nature of the study, i.e. the fact that it was being delivered through an online research platform, education (increasing knowledge or understanding), persuasion (using communication to induce feeling or stimulate action) or enablement (increasing means/reducing barriers) would serve the intervention best. I used APEASE criteria (see Michie, Atkins & West, 2014, p. 23) to narrow down these options, with Practicability being the main evaluation criteria considering study design and the overall objectives of this thesis.

Step 5: Identifying Policy Domains

The mode of delivery of the interventions (i.e. an online experiment) implied that of the available policy domains – *Communication/Marketing, Guidelines, Fiscal measures, Regulation, Legislation, Environmental/Social planning and Service provision* – I would be working with the first one, i.e. communication. Based on the matrix of links between intervention functions and policy categories (Michie, Atkins & West, 2014, p. 138), I narrowed down intervention functions to education and persuasion, since, according to the BCW framework, enablement cannot be delivered through communication.

Step 6: Selection of Behavioural Change Techniques

In Step 6, I selected behavioural change techniques. The Behavioural Change Wheel defines a BCT as "an active component of an intervention designed to change behaviour" (Michie, Atkins & West, 2014, p. 145) and lists 93 such techniques. I followed the steps outlined by the framework and a matrix that links BCTs to TDF domains. Based on this matrix, I narrowed down the possible domains that should be addressed by the intervention to *Goals* and *Social/professional role and identity*. For these two domains, I designed three interventions – one related to *Goals* and two related to *Social/professional role and identity*.

For *Goals*, I chose to develop an intervention that would use three BCTs – goal setting (outcome), goal setting (behaviour) and action planning. Since there were no BCTs associated with *Social/professional role and identity*, I developed two new ones, with the aim of adding them to the BCW if they proved effective. It is also for this reason that the interventions were tested separately, rather than using all these domains/BCTs in one intervention (as was done in Study 2, described later).

Step 7: Identifying Mode of Delivery

The last step of the BCW, before an intervention is implemented, is a selection of a mode of delivery. The BCW lists six such modes of delivery for intervention functions that involve communication – face-to-face modes and distance modes, such as broadcast media, digital media, outdoor media and print media, phone and individually accessed computer programme.
The chosen mode of delivery here was digital media, and specifically Prolific Academic/Qualtrics/Twitter. Since this choice was made at the beginning of the project and was one of the objectives of the research study, I did not evaluate the available modes using the APEASE criteria, as the BCW framework suggests.

Step 8: Intervention (Study 1.2)

Following Steps 1 to 7 lead to the development of three behavioural change interventions, which had the aim of increasing people's *intent* to tweet anti-littering messages.

Pilot study.

To make sure all the instructions were clear, I conducted a pilot study, in which 15 respondents were randomly assigned to four groups (control, *Goals*, *Social/professional role and identity* 1, *Social/professional role and identity* 2) and underwent the manipulations. At the end of the study, everyone was asked to provide feedback on whether the instructions were

clear and if they felt like they exactly knew what to do in the study. Feedback suggested the instructions were indeed clear, so I proceeded to conduct the main study.xs

Main study.

One thousand two hundred participants took part in the study (mean age=34.82; 68% female). They were recruited through Prolific Academic and were paid £0.75 for participation. Only UK residents who had a Twitter account (based on information provided in a person's Prolific Academic profile) were allowed to take part in the study.

Respondents were first asked if they had a Twitter account and how often they used it. If someone answered they didn't use Twitter (despite providing information on her Prolific Academic profile that she was a user), the person was not allowed to participate in the study. Two hundred and nineteen people answered they didn't use Twitter, leaving 980 respondents (mean age=34.82; 67.25% female).

Next, similarly to Study 1.1, participants were asked to evaluate, on a 7-point scale, how big of a problem they thought litter was in the UK. Then, they read instructions stating they were going to answer questions about using Twitter to raise awareness of the problem of litter, by tweeting anti-littering messages. They were provided with a definition – the same one as in Study 1 – of what "anti-littering messages" were. In the next step, participants were randomly assigned to one of four groups – a control group that did not undergo any intervention; a goal setting intervention group; an identity intervention based on the most important life roles; and an identity intervention based on positive self-perception.

Goals intervention.

The first intervention targeted the *Goals* domain. This intervention used three different BCTs – *Goal setting (outcome), Goal setting (behaviour)* and *Action planning*. Specifically, participants assigned to this group were given a goal (as opposed to being given "an opportunity") to tweet at least

three anti-littering messages in the next seven days (BCT 1). They were then instructed to think about the hoped-for outcome of this behavioural goal. Specifically, the instructions read:

> Our behaviours have outcomes that affect not only ourselves but also other people, and the outside world. The more often you do something, the bigger the effect.
>
> On the next page, we will ask you to **describe the hoped-for outcome** – perhaps on your surroundings, your family, friends, other Twitter users, as well as on yourself – **of posting anti-littering messages on Twitter**.

Participants were asked to describe the outcome they hoped would occur if they posted anti-littering messages on Twitter in the next seven days (BCT 2). After having done so, they were guided through setting up a simple action plan (BCT 3), in which they declared:

- *when* they would post these messages (morning, afternoon, evening);
- *where* they would do it (at home, at work, in school or at the university; commuting; out of the house in their spare time; out of their house while running errands; other, in which case they were asked to provide the details);
- *under what circumstances* they would post (an open-ended question);
- *possible topics* of the messages, where they were required to provide at least three and a maximum of seven possible message topics, one for each day.

Social/professional role and identity 1 intervention (Positive self-image).

The goal of the first *Social/professional role and identity* intervention was to link the target behaviour with a positive self-image. Specifically, the aim was to encourage people to think about the positive effects that posting anti-littering messages on Twitter could have, including how a person would feel about herself having done so. Respondents in this group were instructed to describe, in a few words, this feeling.

Social/professional role and identity 2 intervention (Life roles).

The goal of the second *Social/professional role and identity* intervention was to link a person's most important life role with the target behaviour, i.e. to build a link between an important part of a person's identity with twitting. Instructions started with a description of the concept of important life roles. Specifically, the instructions read:

> Each of us has many roles in our lives, such as being a parent, a friend, or an employee. Some of these roles are more important than others.
>
> In this section, we will ask you about **the most important roles of your life**.

Respondents were asked to list their top three life roles and, in the next step, to rank them, from the most important, to the second and third most important ones. In the third step, they read a short description, which aim was to link the key life role with the target behaviour. Specifically, the description read:

> In the previous section, you stated that being a(n) [a person's top life role] is the most important role of your life.
>
> Our life roles influence what we do. For example, if a person's most important role is being a good friend, this person might be more likely to help others than a person whose most important role is being a good worker. On the other hand, a person whose most important role is being a good worker will be more likely to devote a lot of time to her work than someone whose most important role is being a good friend.
>
> Likewise, what we do every day can influence what roles we have in life. For example, if someone helps others a lot, it's more likely that this person will see herself as being a good friend. And a person who spends a lot of time at work will be more likely to see herself as a good worker.
>
> **Every role we have influences what we do and everything we do shapes our life roles.**

Finally, participants were asked to describe how posting anti-littering messages could help them become a better [a person's most important life role].

Control group.

Respondents assigned to control group did not undergo any manipulation. They were instructed that, as a part of this study, they would have the opportunity (as opposed to "a goal", as in the case of the *Goals* intervention group) to tweet anti-littering messages and, in the following step, were asked to write such a message, as described below.

***

Having undergone one of these manipulations, respondents from all four groups were asked to write an anti-littering Twitter message. They were requested to use the hashtag #LetsUnlitterUK. Once they wrote their messages, they were asked to provide basic demographic information and were given the opportunity to tweet. They were shown their message and were told that, if they wanted, they could post it on Twitter, by clicking a *Tweet* button. Clicking the button opened the same Twitter pop-up window as described in Study 1.1, after which participants needed to click a *Tweet* or *Log in and Tweet* (depending on whether they were logged in to their Twitter account or not) button to post the message. If a respondent didn't want to post her message, she could skip to the next question.

In the last question, participants were asked how likely they would be to tweet more anti-littering messages in the future. This question was the main measure of intent, i.e. the key dependent variables in this study.

Step 9: Message Evaluations (Study 1.3)

In a follow-up study, 1231 respondents (mean age=36.41; 66.89% female) were asked to evaluate Twitter messages written by Study 1.2 respondents. This evaluation served as an additional dependent variable measure in Study 1.2. Each person was randomly shown 35 messages, out of the 980. Participants were instructed to evaluate the messages on a 5-point scale, from very bad to very good. In these evaluations, they were requested to think of the following:

- how likely would this message be to draw their attention if they saw it on Twitter;
- how likely would it be to influence their behaviour, for example, to get them to retweet it or to write an anti-littering Tweet of their own;
- the overall feelings it provoked in them.

Results[2]

Intent to tweet.

The *Goals* intervention had a significant impact on intent to tweet (β=.715, p=.000; 95% confidence intervals .383 to 1.046), implying that the BCW framework can be successfully used to design communication-based interventions in the domain of environmental decision-making.

However, neither of the *Social/professional role and identity* interventions was a significant predictor of the dependent variable. Moreover, women were more likely to declare a higher intent to tweet than men (β=.309, p=.000; 95% confidence intervals .080 to .539); as were older people (β=.024, p=.000; 95% confidence intervals .012 to .035); people with *lower* education (β=-.0473, p=.000; 95% confidence intervals -.703 to -.243); those who actively used Twitter (β=.871, p=.000; 95% confidence intervals .637 to 1.105); and who thought litter was a big problem in the UK (β=1.197, p=.000; 95% confidence intervals .775 to 1.618). Overall, the model explained 5.3% of variance (adjusted R^2=.053).

Table 12
Twitter Study 1.2 ordinal logit regression (DV: intention to tweet).

Number of observations	980
LR chi2(8)	156.55
Prob > chi2	.000
Pseudo R-squared	.053

[2] The analysis is based on data that does *not* include information on 30 messages (13.76%) that I wasn't able to match, i.e. there were 30 messages that were posted on Twitter that did not have a corresponding equivalent in the dataset. This issue is addressed further in the discussion section.

Log likelihood = -1407.8627

	Coefficient	Std. Error	t	P>|t|	95% Confidence intervals	
Identity intervention 1	-.041	.160	-.260	.798	-.356	.274
Identity intervention 2	-.124	.160	-.780	.438	.439	.190
Goals intervention	.715	.169	4.23	.000	.384	1.047
Gender	.309	.117	2.64	.008	.080	.539
Age	.024	.006	4.03	.000	.012	.035
Education	-.473	.118	-4.02	.000	-.704	-.243
Concern with litter	1.197	.215	5.56	.000	.775	1.619
Twitter activity	.871	.119	7.29	.000	.637	1.105

Additional measures.

The BCW emphasizes the importance of clearly defining the desired outcome behaviour and performing a behavioural diagnosis (in this case, through a TDF survey) on exactly the same outcome as the intervention will target (Michie, Atkins & West, 2014; p. 31). However, wanting to use the opportunity to more thoroughly test the impact of my interventions, I conducted two more analyses, in which I estimated the effect of the three interventions on actual twitting behaviour and on the quality of messages written. While this approach did not align with the guidelines provided by BCW authors, it was my assumption that a good intervention should influence not only intent but also behaviour and the quality of messages written, even if the diagnosis only targeted intent. Nonetheless, the following results should be treated with caution, as they do not necessarily reflect on the BCW's effectiveness.

A logistic binary regression showed that none of the interventions had a significant impact on whether people actually twitted their messages (see Table 13). The odds ratio for participants in the *Goals* intervention group it was 1.309 (p=.257; 95% confidence intervals .822 to 2.087); for participants in the positive self-image intervention group was .940 (p=.800; 95% confidence intervals .583 to 1.516); and for participants in the key life roles group it was 1.090 (p=.716; 95% confidence intervals .685 to 1.735).

As before, some personal characteristics had an impact on the two dependent variables. Women were twice as likely to tweet than men (odds ratio 2.061; p=.000, 95% confidence intervals 1.445 to 2.939), as were older

people. For every year of age, the likelihood to tweet increased by 5% (odds ratio 1.052; p=.000; 95% confidence intervals 1.035 to 1.069). Twitter activity also increased the probability of the message being posted. People who claimed to use Twitter daily or weekly (as opposed to monthly, yearly; or passively, i.e. only to read other people's posts) were almost twice as likely to post their messages (odds radio 1.860; p=.001, 95% confidence intervals 1.310 to 2.642). Overall, this model explained 8.6% of variance (pseudo R^2=.086).

The quality of messages written did not vary between groups (see Table 14). On average, the messages were given a rating of 3.43, on a 5-point scale, where 5 was "very good". Beta coefficient for the *Goals* intervention was β=-.043 (p=.298; 95% confidence intervals -.124 to 0.038); for the positive self-image intervention it was β=-.018 (p=.655; 95% confidence intervals -.096 to -.060); and for the second identity intervention (key life roles) it was β=-.046 (p=.251; 95% confidence intervals -.125 to 0.033).

Table 13
Twitter Study 1.2 logistic regression (DV: likelihood to tweet).

Number of observations	980
LR chi2(8)	81.99
Prob > chi2	.000
Pseudo R-squared	.086

Log likelihood = -438.105

	Odds Ratio	**Std. Error**	**z**	**P>|z|**	**95% Confidence intervals**	
Identity intervention 1	.940	.229	-0.25	.800	.583	1.516
Identity intervention 2	1.090	.258	.36	.716	.685	1.735
Goals intervention	1.309	.311	1.13	.257	.821	2.087
Gender	2.061	.373	3.99	.000	1.445	2.939
Age	1.052	.009	6.23	.000	1.035	1.069
Education	.730	.125	-1.84	.065	.522	1.020
Concern with litter	2.060	.851	1.75	.080	.917	4.628
Twitter activity	1.860	.333	3.47	.001	1.310	2.642
Constant	.008	.005	-8.50	.000	.003	.025

Table 14
Twitter Study 1.2 multiple regression (DV: average message rating).

Number of observations	980
F(3,976)	0.580
Prob > F	.626
R-squared	.086
Adj R-squared	-.001
Root MSE	.448

	Coefficient	**Std. Error**	**t**	**P>|t|**	**95% Confidence intervals**	
Identity intervention 1	-.018	.040	.655	.655	-.096	.060
Identity intervention 2	-.046	.040	.251	.251	-.125	.033
Goals intervention	-.043	.041	.298	.298	-.124	.038
Constant	3.460	.028	.000	.000	3.404	3.515

Discussion

This study had three main objectives: (1) to test the effectiveness of the BCW approach to intervention design in the context of environmental decision-making and relying on communication as the mode of delivery of an intervention; (2) to develop new BCTs for a TDF domain for which there were no assigned techniques (*Social/professional role and identity*); and (3) to test a new Qualtrics—Twitter interface that allows one to measure real behaviour in online experimental research.

Overall, only one of the interventions, which used BCTs associated with the *Goals* domain, was effective in increasing intent to tweet anti-littering messages. These results provide initial evidence that the BCW can indeed be effectively used to develop communication-based interventions, in the context of anti-littering, pro-environmental decision-making. The two *Social/professional role and identity* interventions I developed, which linked twitting to key life roles and to a positive self-image, had no impact on the outcome variable, making my attempt to develop new BCTs ineffective.

None of the interventions influenced actual behaviour or the quality of messages written – the two additional dependent variable measures. Yet, due to reasons mentioned earlier, predominantly the importance of basing a diagnosis and an intervention on the same behavioural outcome, such

results should not be taken to mean the BCW framework is ineffective. They may simply be an outcome of using intent as the dependent variable in TDF diagnosis and trying to influence two different (albeit related) behaviours in the intervention.

Finally, the Qualtrics – Twitter interface worked well and allowed me to measure how many messages were posted on Twitter, albeit not precisely. What I failed to foresee was that people would change their messages once they were about to tweet them, i.e. when they saw them in the Twitter pop-up window (outside of Qualtrics). This created a problem with matching the tweets, resulting in 30 messages (13.76%) left unmatched.

Study 2

While the results of Study 1 indicated that following the BCW framework may result in designing effective behavioural change interventions, some important questions remained unanswered. First, the TDF diagnosis targeted intent, not actual behaviour and the results did not allow me to make a definitive conclusion about the effectiveness of BCW-derived interventions on actual behaviour. Second, the fact that I was able to effectively influence intent – the main dependent variable measure – did not automatically mean that theory-informed interventions, designed using the BCW, are better than intuition-based ones. It simply meant they may be better than not doing anything. Moreover, there were methodological issues with the design of the newly developed Qualtrics – Twitter interface. Specifically, there was a need to improve tweet match rate.

Study 2 aimed to address all of these, and several additional smaller, methodological issues. Specifically, the key objectives of the changes made in the design of Study 2 were to (1) evaluate the impact of BCW-derived intervention on actual behaviour; (2) compare the impact of a BCW-derived intervention with an intuition-based one; and (3) improve the behavioural measure (Qualtrics – Twitter interface) by increasing the proportion of tweets matched.

Methodology

Study 2 followed the same design as used in Study 1, outlined in Table 9 (see page 57). The target behaviour remained unchanged, as described in Step 1 on page 58.

The theoretical domains framework (Study 2.1).[3]

The TDF survey was modified so that each domain had exactly two statements and of a more similar length (see Table 2 in Appendix C). Since this time the dependent variable was actual behaviour, unlike in Study 1.1, the *Intention* domain was used as an independent variable and was included in the regression.

Participants.

Participants were once again recruited through Prolific Academic and the sample was restricted to UK residents who had a Twitter account (based on information provided in a person's Prolific Academic profile). Since I wanted to be able to measure behaviour, and in some of the previous studies as little as 10% of participants twitted their messages, the sample size was increased to over 1000 so that at least 100 people would tweet. Specifically, 1021 respondents took part in the study (mean age = 32.16; 62% female) and were paid £0.75 for participation.

Procedure.

Participants were first asked to evaluate, on a 7-point scale, how big of a problem they thought litter was in the UK. Next, they were told they were going to see and be asked to evaluate how much they agreed with a series of statements relating to how and why people may use Twitter to raise

[3] Updates to the TDF statements in Study 2.1 and Study 2.1 analysis have been conducted under my direction by Philippa Nation, who has been involved in this project as a part of my supervision of her MSc in Behavioural Economics and Science dissertation. The write-up of the results is my own.

awareness of the problem of litter. They were provided with a definition of what was meant by "anti-littering messages", same as before.

Next, they were shown, in a random order, the 28 TDF statements (see Table 2 in Appendix C) and were asked to evaluate how much they agreed with them, on a 7-point scale. Then, they were asked how often they used Twitter and were requested to write a message, no longer than 140 characters, about litter. They were provided with and requested to use the hashtag #LetsUnlitterUK. In the final step, participants provided demographic data and were given the opportunity to tweet their messages, using the same method described earlier.

Results.

We conducted a logistic regression, using a binary behavioural measure (did – did not tweet) as the dependent variable. The model was significant (χ^2=82.32; p=.000), with a pseudo R^2 of .126. Four domains were identified as significant predictors of twitting – *Cognitive and interpersonal skills* (odds ratio=1.602; p=.016; 95% confidence intervals 1.090 to 2.355); *Beliefs about capabilities* (odds ratio=1.467; p=.007; 95% confidence intervals 1.110 to 1.940); *Reinforcement* (odds ratio=.767; p=.015; 95% confidence intervals .620 to .950); and *Intentions* (odds ratio=1.745; p=.000; 95% confidence intervals 1.381 to 2.205).

Table 15
Twitter Study 2.1 TDF logistic regression.

Number of observations	1,021
LR chi²(8)	82.32
Prob > chi²	0.000
Pseudo R-squared	0.126

Log likelihood = -286.112

	Odds Ratio	**Std. Error**	**z**	**P>|z|**	**95% Confidence intervals**	
Knowledge	0.875	.112	-1.05	0.295	.680	1.124
Skills	1.602	.315	2.40	.016	1.090	2.355
Social/prof role & identity	1.108	.146	0.78	.434	.856	1.435

Beliefs about capabilities	1.467	.209	2.69	.007	1.110	1.940
Optimism	.897	.142	-0.69	493	.657	1.224
Beliefs about consequences	1.215	.211	1.12	.264	.864	1.708
Reinforcement	.767	.084	-2.43	.015	.620	.950
Intentions	1.745	.208	4.67	.000	1.381	2.205
Goals	1.037	.132	.29	.773	.808	1.331
Memory, attention & decision proc	.948	.101	-.50	.615	.768	1.169
Environment	.915	.152	-.53	.595	.661	1.268
Social influences	.784	.101	-1.88	.060	.609	1.010
Emotion	1.055	.193	.30	.768	.737	1.512
Behavioural regulation	.923	.141	-.52	.603	.684	1.247
Constant	.000	.001	-4.97	.000	.000	.012

Main intervention (Study 2.2).

Since none of the key domains overlapped with Study 1.2, I followed Steps 3 to 7 (see Table 9 on page 57) to design a new intervention. Unlike previously, where each intervention addressed only one of the TDF domains, in this study I chose to design one intervention composed of four BCTs, one for each domain. Since this time all domains had specific BCTs assigned to them and there was no need to invent and test new ones, such an approach was warranted.

Participants.

One thousand five hundred fifty-eight respondents participated in the study. However, 8.79% claimed to have not used Twitter and therefore did not fulfil the inclusion criteria, leaving 1421 participants (mean age=37.81; 69.11% female). People were once again recruited through Prolific Academic, using the same selection criteria as previously.

It was my aim to recruit a sample of 1800 however I was unable to do so due to a restricted sample size. Only approximately 10% of Prolific Academic users are also Twitter users and UK residents (according to information provided in personal profiles), reducing a total sample to pool from to around 5,000. Since those who already participated in Study 1 and Study 2.1 were excluded from the sample, a small enough population was left

that I was unable to collect all data as planned before the launch of the study. Participants were paid £0.50.

Procedure.

The study followed a similar structure to Study 1.2, with some methodological changes made to address the issues raised earlier. Like before, participants were first asked if they had a Twitter account and how often they used it. Next, they saw a short, one-sentence introduction, which was added to introduce the topic of littering. Specifically, the introduction read:

> Many people feel that littering is a significant issue in the United Kingdom. This short study concerns attitudes toward littering and the actions people might take to prevent it.

Then, they were instructed, just as in Study 1.2, that they would be asked to write an anti-littering Twitter message and would have an option of twitting it; followed by the explanation of what was meant by "an anti-littering message". At this point, participants were randomly assigned to one of five groups: one of two control groups; one of two BCW intervention experimental groups; or a social norms intervention group.

The control and experimental groups were split into two sub-groups, as a part of a solution to the problem of matching tweets. I assigned a different hashtag to each group, which allowed me to know which experimental group a participant belonged to even if there were no corresponding (matched) tweets in the dataset. While this still did not solve the problem of which respondent specifically posted such a message, it did allow me to at least match this person to a particular group.

To minimize the risk of some hashtags being more attractive than others and possibly influencing behaviour, I created two pairs of "mirror" hashtags, which weren't used on Twitter before this study and which were of the same length: The control group was assigned #DelitterGB and #NolitterUK hashtags, while the experimental group was assigned #DelitterUK and #NolitterGB hashtags. #LetsUnlitterUK was not used here

since it had already existed on Twitter (after Study 1 and Study 2.1) and its presence there may have impacted people's willingness to tweet.

Another significant change made to the set-up of the study was adding another experimental group. One conclusion from Study 1 was that while the BCW approach seemed to yield effective interventions, there was no way of evaluating whether BCW-based interventions were better than intuition-based ones. Indeed, to my knowledge, despite the growing popularity of the framework, there is yet no research that would help assess this. Therefore, this third group was added, which underwent an intervention that used social norms – a BCT that was *not* a significant predictor of tweeting according to Study 2.1 results, yet one that has been shown to work in many domains, including anti-littering and pro-environmental behaviours (e.g. Cialdini, 1987; Cialdini et al., 2006; Cialdini, Reno & Kallgren, 1990; Goldstein, Cialdini & Griskevicius, 2008; Reno, Cialdini & Kallgren, 1993; Rivis & Sheeran, 2003; Schultz et al., 2007). This group was assigned #UnlitterUK hashtag.

The BCW intervention.

The intervention consisted of four BCTs: *Behavioural rehearsal/practice, Anticipation of future reward, Behavioural contact and Verbal persuasion to boost self-efficacy*. Participants were first shown, step by step, what the process of twitting would look like: That they would see a text box with an already typed-in hashtag in which they were to write their message. They also saw instructions, which asked them to write a message no longer than 140 characters and to write the message exactly as they would like to see it on Twitter, even if they chose not to post it. The last sentence was added to encourage people to *not* change their message once they were about to tweet, which was another improvement made, with the goal of decreasing the number of unmatched tweets.

Next, participants saw what their message would look like when they would be given the option to tweet it and once they clicked the "*Tweet*" button (see Figures 1-3 in Appendix C). The final step of the *Behavioural*

rehearsal/practice BCT was a request to mark whether a respondent understood the instructions (all but five people answered "yes").

The second BCT, *Anticipation of future reward*, was an offer to send a note with science-proven tips on how to spend money to increase one's happiness. Specifically, the instructions read:

> We, the authors of this study, are behavioural scientists – we investigate how people make decisions and help people be healthier and happier.
>
> As a thank you for posting an anti-littering message at the end of this study, we will send you a note with science-proven **5 Tips on How to Spend Money to Increase Your Happiness**.
>
> You will receive this note through Prolific Academic.
>
> Please click below if you'd like to receive this note.

Participants could then click whether they wanted to receive the note or not. Overall, 60.15% of respondents said they wanted the note.

Then, participants were asked to commit to posting their anti-littering messages on Twitter, by signing their initials below a commitment statement (*I will tweet an anti-littering message at the end of this study to help raise awareness of the problem of litter.*). Seventy percent (70.39%) of respondents signed their initials. Finally, they saw a message of encouragement, which included a "You can do it!" sentence and a "success kid" meme that read "Hey, you can do it!" (see Figure 4 in Appendix C).

Table 16
Twitter Study 2.2 BCTs.

Domain		BCT	BCT description	BCT details
Cognitive and interpersonal skills	*1*	*Behavioural rehearsal/ /practice*	Prompt practice of the performance of the behaviour one or more times in a context or at a time when the performance may not be necessary, in order to increase skills	A step-by-step description of what the process of twitting will look like later in the study, with print-screens of each step

Reinforcement	*2*	*Anticipation of future reward*	Inform that future reward or removal of punishment will be a consequence of performance of a wanted behaviour	Offer to send a note with top five behavioural science tips on how to spend money to increase one's happiness
Intentions	*3*	*Behavioural contract*	Create a written specification of the behaviour to be performed, agreed by the person, and witnessed by another	A request to sign one's initials by a commitment to tweet statement
Beliefs about capabilities	*4*	*Verbal persuasion to boost self-efficacy*	Tell the person that they can successfully perform the wanted behaviour, arguing against self-doubts and asserting that they can and will succeed	A message of encouragement "You can do it!!!" with the "success kid" meme

Social norms intervention.

Participants in this group were shown a short message, which showcased that many people before had already twitted similar messages. Since the average tweet rate in previous studies was between 10-20%, therefore too low to be used as a social proof message, I used a number showing how many people twitted, rather than a percentage. Specifically, the message read:

> In our previous studies, we asked Prolific Academic users just like you to post on Twitter their anti-littering messages, which included the hashtag #LetsUnlitterUK.
>
> **In response, close to 400 people tweeted!**

Control group.

Respondents assigned to control group did not undergo any manipulation.

***

Next, respondents from all four groups were asked to write an anti-littering message. They were requested to use an appropriate hashtag – #DelitterGB or #NolitterUK if they were in the control group; #DelitterUK or #NolitterGB if they were in the BCW intervention group; and #UnlitterUK if they were in the social norms group. The instructions were the same as in the previous studies, with the one sentence added ("*Please write the message exactly as you'd like to see it on Twitter, even if you choose not to post it*.") at the end to decrease the number of changes made to these messages once people saw them in a Twitter pop-up box and were about the post them online. This small addition improved match rate significantly, resulting in only four tweets in total (1.94%) left unmatched (one in #DelitterGB control group; two in #DelitterUK and one in #NolitterGB BCW intervention group).

Then, participants were given the opportunity to tweet the message, as described in Study 1.2 and shown in Steps 1-3 in Appendix C (see Figures 1-3). If a respondent didn't want to post her message, she could skip to the next question.

Finally, participants were asked to provide basic demographic data and to evaluate how big of a problem they thought litter was in the United Kingdom. This question was moved to the end of the study in order to minimize the risk of influencing behaviour.

Results

On average, 22.53% of people in the BCW intervention twitted their messages, while 11.45% did so in the social norms group and 7.85% in the control group. A logistic regression confirmed the difference between the BCW intervention and control group was significant. The odds ratio for participants in the BCW intervention group was 3.462 (p=.000; 95% confidence intervals 2.393 to 5.008). There was no significant impact of the social norms intervention on behaviour. Odds ratio for participants in this group was 1.533 (p=.080; 95% confidence intervals .950 to 2.247).

Moreover, there was a significant impact of age and frequency of Twitter usage on posting, with older people (odds ratio=1.025; p=.000; 95% confidence intervals 1.011 to 1.039) and those who claimed to have used

Twitter more often being more likely to tweet (odds ratio=1.480; p=.000; 95% confidence intervals 1.304 to 1.680). Other control variables, i.e. gender, education and one's opinion of whether litter was a big problem in the UK, did not influence behaviour, even though these variables were significant predictors of intention to tweet in Study 1.2. Overall, the model explained 10.2% of variance (pseudo R^2=.102).

Figure 3
Twitter Study 2.2 tweet rates.

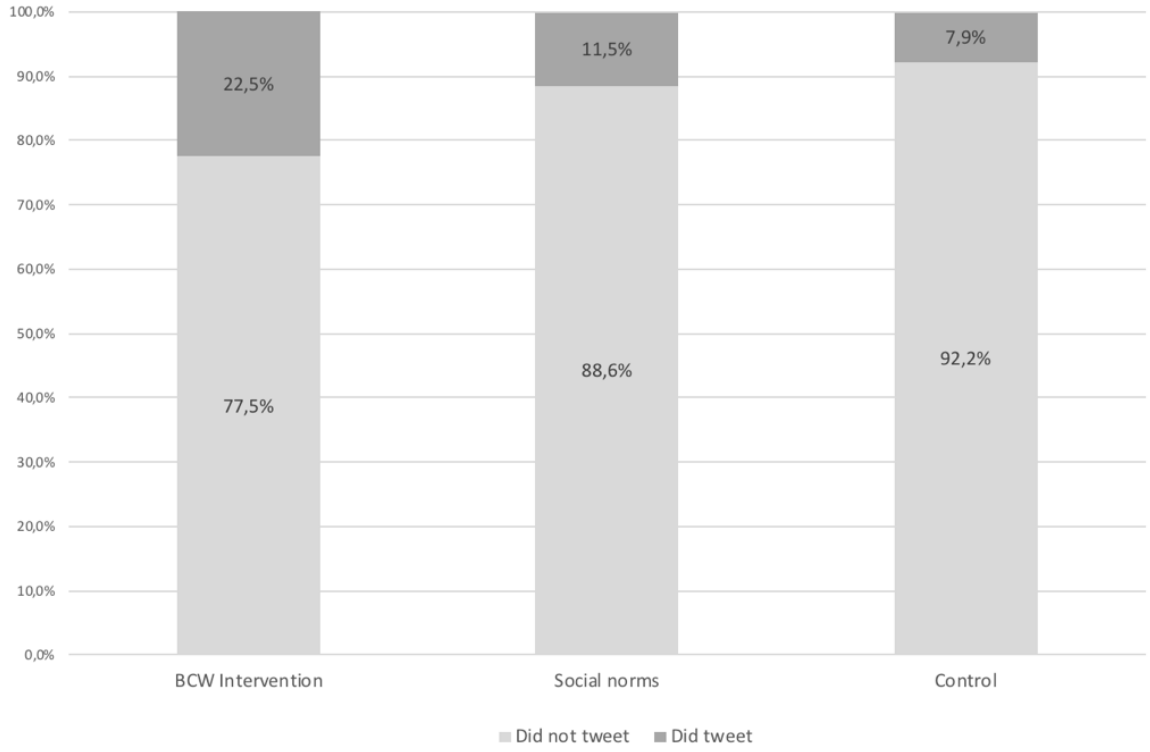


Table 17
Twitter Study 2.2 logistic regression.

Number of observations	1417
LR chi²(8)	117.49
Prob > chi²	.000
Pseudo R-squared	.102

Log likelihood = -518.024

	Odds Ratio	**Std. Error**	**z**	**P>|z|**	**95% Confidence intervals**	
BCW intervention	3.462	.652	6.59	.000	2.393	5.008
Social norms intervention	1.533	.374	1.75	.080	.950	2.474

Gender	1.320	.237	1.55	.122	.928	1.879
Age	1.025	.007	3.59	.000	1.011	1.039
Education	.864	.070	-1.78	.074	.736	1.015
Concern with litter	1.114	.108	1.11	.269	.920	1.348
Twitter activity	1.480	.096	6.07	.000	1.304	1.680
Constant	.006	.005	-6.48	.000	.001	.029

Individual BCTs.

Unlike in Study 1, Study 2.2 intervention was composed of several BCTs, addressing *all* of the significant domains. Considering the main objectives of the study, it was not my aim to evaluate the impact of individual BCTs but rather the intervention as a whole. However, an analysis of individual BCTs yields some interesting observations. Three of the four BCTs required some form of action from the respondents. Specifically, *Behavioural rehearsal/practice* BCT required one to click at the end of the instructions provided if the person understood them. In *Anticipation of future reward* BCT, participants had to state whether they wanted to receive a note with tips on how to spend money to increase one's happiness. Finally, in *Behavioural contract* BCT, participants were asked to sign their initials if they committed to posting an anti-littering message on Twitter at the end of the study. There was no action required in the case of the last BCT, *Verbal persuasion to boost self-efficacy*.

Of 537 people in the BCW intervention group, all but five (99.07%) said they understood the instructions. Three hundred twenty-three (60.15%) said they wanted to receive a note with top five tips on how to spend money to increase one's happiness and 378 (70.39%) signed their initials to commit to tweeting.

Table 18
Proportion of respondents who engaged with individual BCTs.

BCT	Engagement with BCT	Percentage of respondents who *did* engage with the BCT
Behavioural rehearsal/practice	Clicking whether one understood instruction describing what the process of tweeting would look like	99.07%

Anticipation of future reward	Clicking whether one wanted to receive a note with tips on increasing happiness	60.15%
Behavioural contract	Signing one's initials below a commitment statement	70.39%

Since only five people stated they did not understand the instructions in *Behavioural rehearsal/practice*, no further analysis of the impact of this BCT on behaviour was performed. Of those who committed to tweeting by signing their initials *and* who wanted to receive the note, 34.75% twitted; yet among those who neither signed their initials nor wanted the note, only 5.94% did. Among people who did commit but did not want to receive the note, 20.35% twitted, yet no one from the group who did *not* commit but did want the note twitted.

Table 19
Tweet rates for respondents who did (not) engage with BCT 3 and BCT 4.

			Behavioural contract	
			Yes	No
Anticipation of future reward	Yes	Tweet rate Group size	34.75% (265)	0% (58)
	No	Tweet rate Group size	20.35% (113)	5.94% (101)

I conducted three more regressions, to estimate the impact of those two individual BCTs. A regression done only on those who did *not* commit to posting indicated that the impact of *Behavioural contract* on the effectiveness of the entire BCW intervention was significant. Once those who did commit were excluded, the intervention as a whole (i.e. the other three BCTs combined) had a smaller impact on behaviour. The odds ratio of the intervention, in this case, was .547 (p=.183; 95% confidence intervals .225 to 1.330). A regression that included only those participants who wanted to receive the reinforcement note showed that this particular BCT had a weaker

impact on behaviour than *Behavioural contract* (commitment). In this case, the odds ratio of twitting was 1.759 (p=.033; 95% confidence intervals 1.045 to 2.959). Finally, excluding those who committed and/or wanted the reinforcement note, the odds ratio of twitting was .850 (p=.725; 95% confidence intervals .345 to 2.097). This simple analysis indicates that the *Behavioural contract* BCT played a more important role in the effectiveness of the intervention as a whole than the *Anticipation of future reward* BCT.

Table 20
Logistic regression for users who did not engage with BCT 3.

Number of observations	1045
LR chi²(8)	64.35
Prob > chi²	.000
Pseudo R-squared	.108

Log likelihood = -266.612

	Odds Ratio	**Std. Error**	**z**	**P>|z|**	**95% Confidence intervals**	
BCW intervention	.547	.248	-1.33	.183	.225	1.330
Social norms intervention	1.580	.393	1.84	.066	.970	2.573
Gender	1.254	.324	0.87	.382	1.024	1.064
Age	1.044	.010	4.36	.000	1.024	1.064
Education	.933	.111	-0.59	.558	.739	1.177
Concern with litter	1.132	.166	0.83	.399	.849	1.509
Twitter activity	1.744	.180	5.40	.000	1.425	2.135
Constant	.001	.001	-5.72	.000	.000	.012

Table 21
Logistic regression for users who did not engage with BCT 4.

Number of observations	1098
LR chi²(8)	73.49
Prob > chi²	.000
Pseudo R-squared	.104

Log likelihood = -316.225

	Odds Ratio	**Std. Error**	**z**	**P>|z|**	**95% Confidence intervals**	
BCW intervention	1.759	.467	2.13	.033	1.045	2.959
Social norms intervention	1.581	.393	1.84	.065	.971	2.575
Gender	1.322	.313	1.18	.239	.830	2.106

Age	1.045	.009	4.96	.000	1.027	1.064
Education	.899	.096	-1.00	.317	.729	1.108
Concern with litter	1.059	.132	0.46	.645	.729	1.108
Twitter activity	1.732	.162	5.87	.000	1.441	2.080
Constant	.002	.002	-6.12	.000	.000	.014

Table 22
Logistic regression for users who did not engage with BTC 3 nor 4.

Number of observations	987
LR chi²(8)	59.16
Prob > chi²	.000
Pseudo R-squared	.103

Log likelihood = -262.428

	Odds Ratio	**Std. Error**	**z**	**P>|z|**	**95% Confidence intervals**	
BCW intervention	.850	.392	-0.35	.725	.345	2.097
Social norms intervention	1.579	.393	1.84	.066	.969	2.573
Gender	1.237	.320	0.82	.410	0.745	2.054
Age	1.044	.010	4.39	.000	1.024	1.064
Education	.935	.111	-0.57	.570	.740	1.180
Concern with litter	1.144	.168	0.92	.360	.858	1.525
Twitter activity	1.740	.180	5.33	.000	1.418	2.128
Constant	.001	.001	-5.75	.000	.000	.011

Individual hashtags.

Participants assigned to both the BCW intervention and the control groups were provided with two different hashtags – #DelitterGB or #NolitterUK if they were in the control group and #DelitterUK or #NolitterGB if they were in the BCW intervention group. While the hashtags were of the same length and as similar to one another as possible, the perception of their attractiveness could have differed, impacting people's likelihood to tweet. To estimate the impact of these individual hashtags, I conducted one more regression, in which the individual hashtags, rather than experimental groups, served as independent variables.

In line with the results presented so far, both of the control group hashtags (#DelitterGB and #NolitterUK) had a smaller impact on behaviour

than the BCW intervention hashtags (#DelitterUK and #NolitterGB). From the two control group hashtags, #NolitterUK had a bigger impact on behaviour, with odds ratio .513 (p=.029; 95% confidence intervals .282 to .935), than #DelitterGB (odds ratio .797; p=.411; 95% confidence intervals .463 to 1.370), using #UnlitterUK (social norms intervention) as the reference group. Correspondingly, the two BCW intervention hashtags had a similar impact on behaviour. #DelitterUK had an odds ratio of 2.196 (p=.001; 95% confidence intervals 1.362 to 3.542) while #NolitterGB had an odds ratio of 2.317 (p=.001; 95% confidence intervals 1.444 to 3.720). Overall, these results suggest there was no significant impact of individual hashtags within each of the groups, with the control group and BCW intervention group hashtags having a similar odds ratio and confidence intervals within each of the groups.

Table 23
Twitter Study 2.2 individual hashtags logistic regression.

Number of observations	1417
LR chi²(8)	119.54
Prob > chi²	.000
Pseudo R-squared	.104

Log likelihood = -516.998

	Odds Ratio	**Std. Error**	**z**	**P>|z|**	**95% Confidence intervals**	
#DelitterGB (Control)	.797	.220	-.082	.411	.463	1.370
#NolitterUK (Control)	.513	.157	-2.18	.029	.282	.935
#DelitterUK (BCW)	2.196	.536	3.23	.001	1.362	3.542
#NolitterGB (BCW)	2.317	.559	3.48	.001	1.444	3.720
Gender	1.307	.235	1.49	.137	.919	1.861
Age	1.025	.007	3.55	.000	1.011	1.039
Education	.864	.070	-1.79	.073	.736	1.014
Concern with litter	1.112	.108	1.09	.275	.919	1.346
Twitter activity	1.484	.096	6.10	.000	1.307	1.685
Constant	.010	.008	-5.83	.000	.002	.046

Discussion

The main objectives of Study 2 were to (1) evaluate the impact of a BCW-derived intervention that used communication on actual behaviour

in the context of environmental decision-making; and (2) to compare the effect of such an intervention with an intuition-based one, which relied on a social norms message. Additionally, it was my aim to improve the newly developed behavioural measure tool – the Qualtrics – Twitter interface – by increasing the proportion of tweets matched.

Evaluating the impact of the BCW-derived intervention.

The intervention was effective in influencing people's willingness to tweet. Twenty-two and a half percent of people in the BCW intervention group tweeted their messages, while only 11.5% in the social norms intervention group and 7.9% of people in the control group did. The difference in behaviour between the BCW intervention group and the control group was highly significant, while the social norms intervention did not have a significant impact on behaviour. While it was not the main objective of this study, the analysis indicated that the *Behavioural contract* BCT, which targeted the *Intentions* domain was a bigger contributor to the observed change in behaviour than *Anticipation of future reward*, which targeted the *Reinforcement* domain.

Testing a new real behaviour measure (Qualtrics – Twitter interface).

There were two changes made to the Qualtrics – Twitter interface, which improved the proportion of tweets matched. Most importantly, I added a one-sentence request before participants were to write their messages, asking them to write them exactly as they would like to see them on Twitter, even if they later chose not to share them. This one change resulted in a decrease of unmatched tweets from 18.7% in Study 1.2 to 1.94% in Study 2.2. Moreover, each group was assigned a different hashtag so that unmatched tweets could be assigned to a proper group, if not to a specific individual within that group. (Since only four tweets were unmatched, they were left out of the analysis).

General Discussion

This research project had three main goals. First, its aim was to evaluate the effectiveness of theory-derived communication-based interventions, in line with the overall objective of my PhD work. To achieve this goal, I set out to verify whether the Behavioural Change Wheel framework could be effectively used in the context of environmental (rather than health) decision-making and if this theory-based approach would have a greater impact than an intuition-based one. The second objective was to develop and test two new identity-based interventions, which – if effective – could be added to the BCW framework. Finally, it was my goal to develop and test a new behavioural measure – the Qualtrics – Twitter interface – which would allow researchers to merge online research with social media, to efficiently test other interventions and to do so in a *simple* way, in line with the overall theme of the work described in this thesis.

The Behavioural Change Wheel

Based on the results of the two studies, the BCW is not only an effective approach to designing behavioural change interventions but possibly a better one than other intuitively-chosen, commonly used techniques, such as social norms, if approached methodically. The authors of the BCW clearly state that the first crucial step when using the framework is a precise definition of the target behaviour (Michie, Atkins & West, 2014, p. 31). As the two studies showed, this precision in defining the hoped-for outcome may be key to generating a visible change. In Study 1, the behavioural diagnosis (Study 1.1) was focused on intention, rather than behaviour, and the intervention did increase intent to tweet, but not actual behaviour. In Study 2, on the other hand, the diagnosis was conducted using actual tweeting as the dependent variable. Not only did such a diagnosis result in different domains being identified as key mediators of the target behaviour but also the second intervention (Study 2.2) increased the likelihood to tweet by threefold, as compared with the control group. These results suggest that, in line with the authors' recommendation, it is

imperative to conduct a behavioural diagnosis on exactly the same target outcome as the intervention will aim to change,
not treating intentions and declarations as proxies of action.

Although warranted, this requirement may result in the Behavioural Change Wheel not being as commonly used in the field as it could be, or, in other words, not being simple enough to use. It may not always be feasible to measure real behaviour when conducting a diagnosis, whether using a questionnaire or an interview-based form of the TDF. While it is relatively easy to measure behaviour using the Qualtrics – Twitter interface, it could prove impossible to apply the same approach to, for example, actual littering behaviour. Such a TDF study would require one to (1) conduct a survey or a series of group interviews; and (2) to measure the amount of litter dropped or picked up by the participants. Considering the practical issues associated with measuring litter, such a set-up seems costly and problematic, possibly unfeasible, and may result in either a diagnosis not being conducted or researchers relying on people's declarations of intent instead.

Therefore, a key issue that needs to be addressed before the BCW can be widely used in the field is the practicality and validity of using the TDF to identify behavioural barriers/enables. A good and practical tool should use actual behaviour as the dependent variable measure, rather than intent, and there needs to be a way to use it outside of a narrow field of policy or closed networks such as hospitals. Moreover, a good tool should also tap into automatic, unconscious motives (independent variables), yet currently, the TDF relies on declarations, gathered through the means of surveys or interviews.

One way this problem could be addressed is by quantifying the link between online "proxy" and offline behaviours, e.g. twitting anti-littering messages and not littering or picking up litter. If such correlation (or even causation) could be estimated, it could result in a behavioural diagnosis being performed online, through the use of simple-to-use tools such as Qualtrics – Twitter interface; and an intervention targeting and measuring real-world, offline behaviour. This approach would be yet another important step towards the simplification of application of behavioural change theory and evidence-based approach outside of the field of public policy.

Moreover, results of Study 2 also imply that some BCTs have a greater impact on behaviour than others. The BCT that targeted *Intentions* domain seemed to have been more influential than the *Reinforcement* BCT, in line with the TDF results, where *Intentions* was a more significant domain than *Reinforcement*. Likewise, *Social influences* was not a significant predictor of behaviour and the social norms message did not have a significant impact on behaviour.

While my research does not allow to make a definitive conclusion, these results point to the fact that it may be enough to address just some BCTs – the ones that are the stronger predictors of behaviour – rather than all. Considering how costly and complex the setting up of a filed intervention can be, it would be useful to know whether indeed all significant barriers/enablers of a behaviour must be addressed to elicit a desired behaviour; or if maybe an approach can be developed that would allow a choice architect to prioritize and evaluate which ones must be addressed and which ones can be left out for a change to take place. Whilst the matter of resources was not an issue in this project, in the real world, this is of great importance. With the number of social issues to be solved and the often-limited resources devoted to pro-social projects, any simplification of behavioural change theory application should be of great benefit.

Real Behaviour Measure (Qualtrics – Twitter Interface)

One way of simplifying the application of behavioural change theory to real-world problems was my development of a novel behaviour measure, the Qualtrics – Twitter interface. With the few simple changes made in Study 2, the tool proved to be an effective approach to conducting academic research focused on eliciting and measuring changes in actual behaviour.

The interface allows one to measure *real* behaviour, in a more real-world setting (than, for example, laboratory experiments), without all the downsides of field studies. Moreover, it lets researchers take advantage of the growing popularity of online research (Peer at al., 2016), by providing a way to merge online research with an important aspect of people's everyday lives that is social media.

An obvious restriction of the interface is that it allows one to only access Twitter users and to only measure their actions online. Yet with so many people using the internet and social media nowadays, the downside of not being able to access diverse populations of respondents is no longer an issue. Almost all adults between the ages of 16 and 54 and 78% of people 65 to 74 in the United Kingdom use the internet. Usage in the oldest age group has increased by approximately 50% between 2011 and 2017, and by over 100%, from 19.9% to 40.5%, for people over 75 years of age (Office for National Statistics, 2017). It is estimated that more than a quarter of the UK population (17.1 million people) will use Twitter by the end of 2018 (Statista, 2018b), with over 11 million using it daily. This data shows that Twitter has become a mass platform for people of all ages, indicating that the problem of limited access to older or less privileged populations is no longer an issue.

Moreover, it is now generally accepted that social media can be used to change offline behaviours too (Hawn, 2009; Wakefield, Loken & Hornik, 2010). Conveying a message or getting people to do something online can translate into a changed behaviour in the real, offline world as, for example, the analysis of the 2016 US presidential election and the role of Twitter and Facebook in its outcome showed (Allcott & Gentzkow, 2017; Bessi & Ferrara, 2016; Bond et al., 2012). This fact suggests solutions such as the Qualtrics – Twitter interface and, in more general terms, simple communication-based social media interventions can have a significant and visible effect on encouraging people to behave pro-socially and to be more engaged in societal issues.

CHAPTER FOUR

Establishing a desired social norm to help clean up Great Britain: A behavioural change intervention

Introduction

Despite the cost of cleaning up litter the UK – close to £1 bn yearly (Keep Britain Tidy, 2014b) – looking at streets, parks, other public areas and pictures and articles posted on social media, one can easily conclude that Great Britain is still one of the dirtiest countries in Europe. While there are no official rankings quantifying the scale of the problem compared to other European countries, data shows that the amount of at least some types of litter, such as beach litter, is growing (Marine Conservation Society, 2017; Statista, 2018a) and surveys have consistently shown that people rate litter as a high priority issue for the local environment (DEFRA, 2013).

Behavioural science research indicates that social norms play an important role in shaping people's behaviours, including littering (Kallgren, Reno & Cialdini, 2000). People look to others for cues as to what is appropriate in a given context. These cues come not only from seeing a behaviour as it happens, e.g. seeing someone drop a wrapper onto the ground, but also through observing the effects of past behaviours (Dur & Vollaard, 2013; Finnie, 1973; Geller, Witmer, & Tuso, 1977; Krauss, Freedman, & Whitcup, 1978; Reiter & Samfuel, 1980). Seeing a park filled with litter can be a signal that littering is accepted in a particular location. Similarly, seeing a clean park, where all litter has been properly disposed of, is an indication that using bins is the norm and that, just like others, one should use bins too. Cialdini, Reno and Kallgren (1990) were able to estimate this impact more precisely, showing that in locations where two or fewer pieces of litter were visible, the social norm was to *not* litter; whereas in locations where three or more pieces of litter were visible, the majority of people littered.

Littering is a complex behaviour and not an easy one to change (Kolodko & Read, 2018). Yet, as research on the impact of social norms indicates a new norm – of clean streets, parks and other public spaces – could help drive the desired change (Cialdini, Reno & Kallgren, 1990). In the UK, it is mostly local councils that are responsible for cleaning up litter, emptying overfilled bins and dealing with fly-tipping (DEFRA, 2013).

Nonetheless, the problem of litter remains (Keep Britain Tidy, 2015), suggesting that councils are not cleaning up enough, or fast enough.

A smartphone app called LitterGram has been recently developed to address this issue. LitterGram allows its users to take pictures of litter and to post them in the app and, if a user wishes to, also on Twitter. A picture is automatically geotagged, based on a location where it was taken, and a council responsible for cleaning up the litter (location) is tagged and notified of the need to clean up a specific area.

LitterGram's main aim of encouraging local councils to clean up litter is achieved in two ways. First, councils can use the app to learn about litter that needs to be cleaned in their jurisdictions. Because location information is based on GPS data it is very accurate, making it easier for councils to know where their involvement is needed than if they were to use e-mail or online requests from their websites, as it currently the norm. Second, by posting pictures, users exert pressure on councils to clean up litter that hasn't been cleaned up. The more people use the app, the more pressure is exerted, through social media, and the greater the chance that litter will be cleaned up, helping to establish the desired social norm of clean public spaces (LitterGram, n.d.).

At the time of my research, LitterGram had approximately 9,500 users, yet only around 40 pictures were posted daily. Seeing a great potential in generating positive social impact, the goal of my research was to encourage LitterGram users to use the app more and to do so through a simple, communication-based intervention. Like in the case of the Twitter study, the intervention was based on the Behavioural Change Wheel framework (the BCW; Michie, Atkins & West, 2014), which allowed me to design a complex intervention and to approach the design process in a systematic way, relying on well-established psychological theories that are at the root of the BCW (see Chapter 3). The second objective of this project was, as in the Twitter study, to test the effectiveness of the Behavioural Change Wheel in the context of environmental decision-making. The BCW is being widely used by policy-makers and other choice architects but its use has been mainly restricted to health decision-making. Moreover, while popular, its

effectiveness in the field is yet to be confirmed (see Chapter 3 for literature review on the BCW).

E-mail-Based Interventions

With 82% of the British population using e-mails (Statista, 2018c), e-mail newsletters can be a useful, practical and cheap channel to deliver behavioural change interventions to diverse populations. Indeed, previous research suggests that e-mail-based interventions can be effective in generating behavioural change. However, to date, few studies used a more comprehensive and theory-based approach, in which several behavioural change techniques were used in a systematic way, as was the case in this project.

The majority of interventions I was able to identify (through a Scopus search in which I looked for publications that used the words "behavioural", "intervention" and "e-mail" or "newsletter" in the title, abstract or as a keyword) used e-mail in a supportive role, in combination with other techniques or channels (e.g. Brendryen et al., 2017; Dudziński et al., 2016; Griffin et al., 2018; Houston et al., 2015; Hutchesson et al., 2016; Levenson et al., 2016; Limaye et al., 2017; Ngamruengphong et al., 2015; Schweier et al., 2018; Skolarus et al., 2017; van Dijk et al., 2017; Young et al., 2017; Young et al., 2018; Zwickert et al., 2016). The studies that used only e-mails typically relied on one of three BCTs: feedback (Carrico & Riemer, 2011; Chambliss et al., 2011; Dennis & Horn, 2014; Emeakaroha et al., 2014; Kramer & Kowatsch, 2017; Leung et al., 2017; Moreira, Oskrochi & Foxcroft, 2012; Taverez et al., 2017), reminders (e.g. Abel et al., 2015; Bradley et al., 2017; Greaney et al., 2012; Murphy & DuPietro, 2012; Petrella et al., 2017; Robertson, 2016; Robinson et al., 2014) or information provision/education (Kattlemann et al., 2014; Kothe & Mullan, 2014; Morgan, Mackinnon & Jorm, 2013; Plotnikoff et al., 2010; Poddar et al., 2012; Schneider et al., 2015).

Several other publications reported e-mail-only-based interventions that used other BCTs. Four of these studies compared the impact of generic

versus personalized e-mails, showing that personalised messages could have a greater impact on increasing physical activity than generic ones (Hageman, Walker & Pullen, 2005; Short et al., 2014; 2015; Walker et al., 2010; 2011; Yates et al., 2012). Other publications described interventions that did not rely on a specific methodology, framework or theory, and which had a mixed effect. For example, Gunter et al. (2017) aimed to reduce the number of returns of newly adopted dogs to a shelter. They sent e-mails to new dog owners (who adopted their pets) with advice on dog behaviour and human activity, as well as invitations to join weekly dog walks. People from the intervention group were not significantly more active than those in control group, nor were they less likely to return their dogs. Leone et al. (2016) used e-mails to promote cancer screening and physical activity among an urban African American population. They sent out a series of three e-mails, over a six-month period, addressing cancer screening and physical activity behaviours but were unable to influence either of the outcome variables. Block et al. (2008) designed an email-based intervention to increase physical activity, reduce added sugar, saturated and trans fats consumption and to increase fruit and vegetable consumption. Their intervention consisted of an assessment, followed by feedback, weekly goal-setting, tips, reminders and promotion of social support and was successful in changing the target behaviours. Finally, Simons-Morton et al. (2005) designed an intervention, in which families with teenage children who had recently received their drivers' licenses, received newsletters with persuasive messages about high-risk teenage driving and a parent–teenager driving agreement. Patents who received these newsletters reported stricter limits on teen driving, at 12 months, compared to parents from a control group, who received standard information on driver safety.

One reason for the mixed effectiveness of the aforementioned interventions can be the fact that they did not rely on theory nor used a systematic approach to selecting the right behavioural change techniques. Previous research suggests that theory-based interventions are more effective than ones that rely on intuition (Abraham et al., 2009; Albarracin et al., 2005; Noar & Zimmerman, 2005). Indeed, the e-mail-based interventions that did use a theory-informed approach, while few, were all effective in

generating a behavioural change. For example, Parrott et al., (2008) designed a three-week study in which e-mails were developed using Theory of Planned Behaviour (TPB; Ajzen, 1985, 1991; Ajzen & Madden, 1986). Research participants first filled out a self-reported TPB measure. Next, they received positively or negatively framed e-mails, delivered every other day over the period of two weeks. More frequent exercise behaviour was reported by the positive-frame group, as compared to the negative-frame group and a control group. Similarly, Blake et al., (2017) showed that TPB-based e-mails had a greater impact on increasing physical activity than text messages; and Kothe, Mullan and Butow (2012) were able to increase fruit and vegetable consumption among Australian students through an e-mail-delivered intervention, develop based on TBP. Two more theory-informed interventions, one using messages based on a habit framework (Rompotis, Grove & Byrne, 2014) and one that used a cognitive behavioural therapy approach (Trockel et al., 2011) proved to be effective in changing health-related behaviours as well.

The key learning that comes from this literature review is that while e-mails are ubiquitous and simple to use, so far there have been few attempts at designing a theory- and evidence-based approach to applying behavioural insights to this form of communication, with the aim of changing behaviours. While several studies did rely on theory, each of these studies used only one theory (mostly Theory of Planned Behaviour), implying there is a need for a more comprehensive and methodical approach. This is where the Behavioural Change Wheel can be of help, as this framework integrates 33 different theories and guides a choice architect how to easily use them in practice. Therefore, the objective of this study was to design an e-mail-based intervention with the help of the BCW, to outline a methodology of how to approach such a task and, importantly, to report results. To my knowledge, these objectives make this study the first one to use the BCW in the context of non-health decision-making and in e-mails. It is also one of the first studies to follow the framework in its entirety and to report results of such an intervention.

Methodology

This study followed the BCW approach to behavioural change intervention development, as described by Michie, Atkins and West (2014) and in Chapter 3. First, I identified the target behaviour (Step 1) and designed a survey, based on the theoretical domains framework, to identify key mediators of the selected target behaviour (Step 2). Next, I conducted the survey (Study 1) and, based on results and the BCW methodology, identified the best behavioural change techniques to use in the intervention (Steps 3 to 7). I then designed and conducted the intervention (Step 8/Study 2), in which respondents were asked to post pictures on LitterGram. Finally, I conducted a follow-up survey (Step 9/Study 3), to evaluate which of the BCTs used in the intervention had the biggest impact on behaviour and evaluated the effectiveness of the intervention (Step 10).

Table 24
LitterGram research project/BCW steps.

	Step	Description
1	Problem definition	Define the problem in behavioural terms; select and specify target behaviour
2	Theoretical domains framework questionnaire development and distribution	Develop a list of statements relating to 14 domains; set up a survey; distribute the link to the survey to LitterGram users via a newsletter
3	Key domains (Study 1)	Identify key behavioural mediators of the selected target behaviour
4	Identify intervention functions	Match the identified domains with the BCW interventions functions
5	Identify policy domains	Match interventions functions with policy domains
6	Identify behavioural change techniques	Select and develop BCTs to be used in the intervention
7	Identify mode of delivery	Select mode of delivery for the chosen BCTs
8	Intervention (Study 2)	Conduct the intervention (main experiment)
9	BCT evaluation (Study 3)	Evaluate the impact of individual BCTs on behaviour change
10	Evaluation	Evaluate the effectiveness of the intervention

Step 1: Problem Definition

The first step of the Behavioural Change Wheel is to define a problem in behavioural terms and to select and specify a target behaviour. The target behaviour was defined as follows in this study:

- Who needs to perform the behaviour? *LitterGram users, who are subscribed to LitterGram newsletter.*
- What do they need to do differently to achieve the desired change? *They need to post at least three pictures of litter on LitterGram every week*[4] *of the intervention. By "litter" I mean any of the eight categories listed in the LitterGram App, i.e. litter, fly tipping, roadworks mess, filthy or broken sign, potholes, dog mess, overfilled bin, graffiti.*
- When do they need to do it? *Anytime they see litter.*
- Where do they need to do it? *On LitterGram.*
- How often do they need to do it? *At least three times a week during the six-week intervention period.*
- With whom do they need to do it? *Alone.*

Step 2: The Theoretical Domains Framework Questionnaire Development and Distribution

To identify barriers/enablers of posting on LitterGram, I developed a questionnaire based on the theoretical domains framework. The TDF is composed of 14 domains: *Knowledge; Skills; Memory, attention and decision processes; Behavioural regulation; Social/professional role and identity; Beliefs about capabilities; Optimism; Beliefs about consequences; Goals; Reinforcement*; and *Intentions*. The questionnaire was developed based on statements outlined for each of the 14 domains in Huijg et al., (2014). See Table 1 in Appendix D for a list of the statements.

[4] For reasons related to data availability, described later in this chapter, the analysis was done for average number of posts per day, not per user per day. Therefore, the goal of posting "at least three times per week" was not taken into account when evaluating the impact of the intervention. Rather, the goal was to significantly increase LitterGram usage.

The survey was set-up in Qualtrics and distributed to LitterGram users via a newsletter. The first of the two e-mails with a link to the survey was sent on December 20th, 2016, to 8112 people (see Figure 1 in Appendix D for previews of the two e-mails sent). Of those, 2389 (29.45%) opened the e-mail and 266 (3.27% of all recipients and 11.13% of those who opened the e-mail) clicked on the link to the survey. The second of the e-mails was sent on December 23rd to 8025 people. Of those, 1957 (24.39%) opened the e-mail and 100 (1.24% of all recipients and 5.21% of those who opened the e-mail) clicked on the link. I was not able to collect data on the percentage of "overlaps", i.e. information on which people opened both e-mails. Therefore, there is no way of knowing how many of the 1957 people who opened the second e-mail also opened the first e-mail. Overall, 247 people filled out the survey (mean age=52.86, 27.8% female). Forty-five of those only answered the first couple questions and therefore their data was removed from the dataset. The subsequent analyses are based on responses from 202 participants.

Step 3: Identifying Key Domains (Study 1)

Procedure.

First, participants were told they were going to answer questions about posting pictures of litter on LitterGram. They were provided with a definition of what was meant by "anti-littering messages". Specifically, they read:

> By "litter" we mean any waste products that have been improperly disposed of, at an inappropriate location. Litter can be as small as a cigarette butt or a chewing gum dropped on the ground; or as big as bin bags left behind, an overfilled bin, or fly-tipping.

Next, participants were asked whether they had ever posted on LitterGram and, if they answered "yes", they were asked how many times they had posted a picture in the previous seven days, with possible answers ranging from zero to five or more times. Next, they saw the 33 TDF statements (see Table 1 in Appendix D), shown in a random order, and were

asked to evaluate how much they agreed with each of the statements on a 7-point scale, from "Strongly disagree" to "Strongly agree". Participants were then asked about their intent to post on LitterGram in the next seven days, with possible answers coded on a 5-point scale from "Zero" to "Five times or more". Finally, everyone was asked to provide basic demographic data (gender, age, where in the UK they lived and whether they had a Twitter account).

Results.

Internal consistency of the TDF scales.

First, I performed a Cronbach Alpha analysis (see Table 28) to measure the internal consistency of the 14 TDF scales. Because of the need to keep the survey relatively short, most of the domains were composed of only two statements. Two domains (*Goals* and *Intention*) were one-question scales, five domains (*Memory, attention and decision processes; Behavioural regulation; Environmental context and resources; Goals; Reinforcement*) were composed of three statements and one domain (*Beliefs about consequences*) was composed of four statements. For every domain that had three or more statements, I removed an item, based on the results of the analysis, to increase its internal consistency. (Items that were removed from the analysis are marked with an asterisk in Table 1 in Appendix D). All subsequent analyses are based on this shorter version of the TDF.

Overall, three scales (*Memory, attention and decision processes; Goals; Beliefs about consequences*) had a Cronbach's Alpha of 0.7 or higher, whereas three (*Behavioural regulation; Environmental context and resources; Reinforcement*) had a lower score. These lower scores seemed justified considering that the statements within each domain were not homogeneous, i.e. they related to diverse areas of a person's life/behaviours.

Bearing in mind the number of domains in the TDF and the need to keep the survey short, not wanting to discourage LitterGram users from participating in the study, I believed the data to be reliable and I, therefore, proceeded to design an intervention based on the results. Moreover,

the statements were based on a previously validated framework (see Huijg et al., 2014), which also supports the validity of the questionnaire, despite the arguably low values of Cronbach's Alpha coefficients.

Table 25
Cronbach's Alphas for LitterGram TDF.

Domain	Number of items	Cronbach's Alpha	Alpha after item removed
Knowledge	2	-	-
Cognitive and interpersonal skills	2	-	-
Memory, attention and decision processes	3	.623	.769
Behavioural regulation	3	.485	.390
Social influences	2	-	-
Environmental context and resources	3	.500	.666
Social/professional role and identity	2	-	-
Beliefs about capabilities	2	-	-
Optimism	1	-	-
Intention	1	-	-
Goals	3	.374	.706
Beliefs about consequences	4	.771	.763
Reinforcement	3	.312	.314
Emotion	2	-	-

Key domains.

Using a backwards exploratory method, I conducted a series of multiple regressions, using the *Intention* scale as a predictor for whether LitterGram users would post pictures in the App. Based on the results, I selected a model with three predictors/BCTs to be used as the basis for subsequent intervention development. The model was significant ($F_{(9,202)=}25.94$; p=.000), with an R^2 of .282. The three identified domains were *Behavioural regulation* (Standardized β=.203; p=.004); *Emotions* (Standardized β=.117; p=.000); and *Beliefs about consequences* (Standardized β=.133; p=.049).

Table 26
LitterGram TDF multiple regression.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
	.531	.282	.271	1.246	.282	25.938	3	198	.000	2.186

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	120.839	3	40.280	25.938	.000
Residual	307.428	198	1.553		
Total	428.322	201			

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-1.009	.636		-1.586	.114		
Consequences	.187	.095	.133	1.978	.049	.803	1.246
Emotions	.546	.117	.330	4.672	.000	.726	1.378
Behavioural Regulation	.302	.102	.203	2.9747	.004	.767	1.304

Step 4: Identifying Intervention Functions

The BCW lists nine functions an intervention can serve (education, persuasion, incentivisation, coercion, training, restriction, modelling and enablement) and the next step of the framework is to identify such a function. Since this intervention was going to use newsletters, I chose education (increasing knowledge or understanding) and enablement (increasing means/reducing barriers) as intervention functions. Specifically, messages related to *Beliefs about consequences* were going to address the education function, whereas messages referring to *Emotions* and *Behavioural regulation* were going to address the enablement function.

Step 5: Identifying Policy Domains

The mode of delivery of the intervention (i.e. a series of newsletters) meant that of the available policy domains (*Communication/Marketing, Guidelines, Fiscal measures, Regulation, Legislation, Environmental/Social planning and Service provision*) I would be working with the first one, i.e. *Communication*.

Step 6: Selection of Behavioural Change Techniques

A behavioural change technique (BCT) is an active component of an intervention designed to change behaviour (Michie, Atkins & West, 2014, p. 145) and the BCW lists 93 such techniques. Considering the mode of delivery, I designed an intervention that used three BCTs, one for each key domain: *Social and environmental consequences; (Monitoring of) emotional consequences; Self-monitoring of behaviour*, as described in Table 27 below.

Table 27
LitterGram study BCTs.

Domain	BCT	BCT description	BCT details
Beliefs about consequences	*Social and environmental consequences*	Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behaviour	Information on positive consequences of posting on LitterGram *or* negative consequences of not posting on LitterGram
Emotions	*(Monitoring of) Emotional consequences*	Prompt assessment of feelings after attempts at performing the behaviour	A request to evaluate how posting/not posting on LitterGram in the previous seven days made the person feel
Behavioural regulation	*Self-monitoring of behaviour*	Establish a method for the person to monitor and record their behaviour(s) as part of a behaviour change strategy	Information on how many pictures the person posted on LitterGram in the last seven days

Step 7: Identifying Mode of Delivery

The BCW lists six modes of delivery for *Communicatio*n—based interventions – face-to-face modes and distance modes (e.g. broadcast, digital and outdoor and print media). My chosen mode of delivery was digital media, and specifically e-mail.

Step 8: Intervention (Study 2)

Steps 1 to 7 lead to the development of a behavioural change intervention, which consisted of three BCTs and which addressed three barriers to behavioural change identified in the TDF survey.

LitterGram newsletter subscribers were randomly allocated to two experimental groups, with 50.01% (4 550) assigned to Group 1 and 49.99% (4 538) assigned to Group 2. Both groups received the same e-mails, with the only difference being a time delay, i.e. the second group started receiving e-mails two weeks later than the first group. The intervention started on a Friday (16th of June for Group 1 and 30th of June for Group 2) and ran for six weeks. See Table 2 in Appendix D for a detailed intervention e-mail schedule.

On every Friday during the intervention period, LitterGram users received an e-mail with *Social and environmental consequences* BCT. I chose Friday as the day to send e-mails with reminders of consequences of (not) posting, assuming weekends were the time when people were more likely to be outdoors and to use the App. There were three types of messages, each written in a positive (gain) and a negative (loss) frame (see Figures 2 and 3 in Appendix D for previews of the six e-mails). The order in which the six e-mails was sent was randomised.

After the weekends, on every Tuesday, participants received e-mails with the second of the three BCTs – *Monitoring of emotional consequences* (see Figure 4 in Appendix D). In these e-mails, recipients were asked to evaluate how they felt – on a 3-point emoji scale that used a frowning face, a neutral face and a happy face – about their activity on LitterGram in the previous seven days. Depending on whether the person had or hadn't posted

in this period, the e-mails either asked one to evaluate how they felt about posting (if they did post) or how they would feel had they posted (if they hadn't). I chose to ask the non-posting group about how they would have felt about posting, rather than how they felt about *not posting*, in order to shift people's focus to positive emotions rather than making them feel bad about not using LitterGram.

Two days later, on Thursdays, everyone received an e-mail with their progress update and an encouragement to post at least three times in the upcoming week. Specifically, every person was provided with information how many times they had posted on LitterGram in the previous seven days, which was a way of delivering the third BCT, *Self-monitoring of behaviour* (see Figure 5 in Appendix D).

The next day, on a Friday, participants received another Friday e-mail with information about positive consequences of posting on LitterGram or negative consequences of not posting and so on, for six weeks and a total of 18 e-mails.

Step 9: BCT Evaluation (Study 3)

After the intervention, two more e-mails were sent, one and a half and three weeks after the intervention, with a link to another TDF survey and a request to participate in the study (see Figure 6 in Appendix D). Since the intervention included three BCTs, I conducted this follow-up survey to evaluate the impact of each of the three BCTs individually. This was done by sending out the same version of the TDF survey people filled out before the intervention (Study 1). However, due to a very low response rate, I was unable to perform this analysis.

Results

It was my aim to conduct a detailed evaluation of the intervention, in which I would estimate not only the impact of the intervention as a whole but also of its individual components, including variables such as which e-mail type (BCT) and sub-type (positive vs. negative frame of consequences

used in the Friday/BCT 1 e-mails) had the biggest impact on behaviour. However, despite best attempts at designing the study methodology carefully and agreements with LitterGram on the type of data to be recorded, this was not possible.

First, I wasn't able to obtain data on which emoji study participants clicked on, making a more detailed analysis of the impact of BCT 2 impossible. Second, I was unable to obtain precise information regarding the number of active LitterGram users on each day, resulting in the analysis being conducted on the average number of posts per day, not per user. Most importantly, however, there was an issue with a discrepancy between e-mail sent and open dates. The more detailed analysis of the intervention relied on the assumption that people would read e-mails on the days they received them, and on those days only. However, as data showed, this was not the case. Some people opened e-mails with a delay and/or several at a time. Hence, it wasn't possible to identify which BCT impacted a person's behaviour on a particular day. For example, if a person opened both a Tuesday e-mail and a Thursday e-mail on a Thursday, there was no way of knowing whether her behaviour was impacted by BCT 2 or BCT 3. Therefore, the subsequent analysis treats the intervention as a whole.

Overall, 9 078 LitterGram users received intervention e-mails. The average open rate of all e-mails was 25.70%. Due to data availability, the subsequent analyses were conducted on all data, not only on the opened e-mails. To evaluate the impact of the intervention, I conducted a trend analysis of LitterGram usage, combined with a series of regressions and ANOVAs, comparing LitterGram usage in four periods: three months preceding intervention, eight weeks of the intervention (combined data for Groups 1 and 2), three months after the intervention and a period equivalent to intervention from the previous year, i.e. June 16th to August 4th, 2016. Additional econometric modelling techniques were used to estimate a possible impact of autocorrelation and seasonality in LitterGram usage on results.

Usage Trends for Four Intervention Analysis Periods

Data were divided into the following four analysis periods:

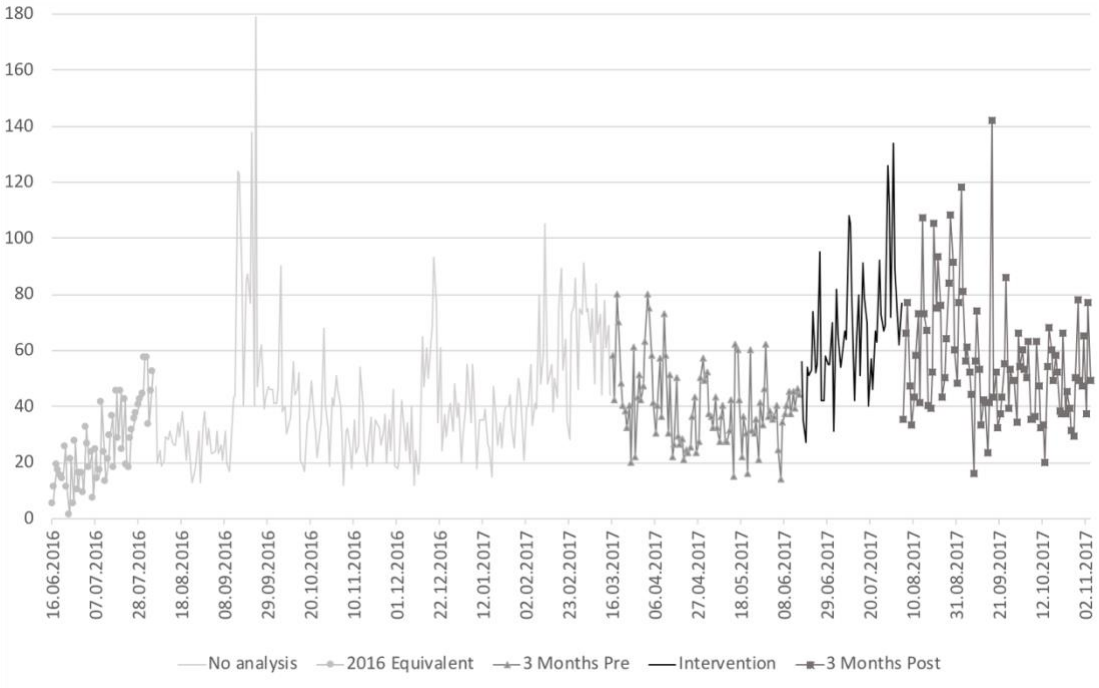
- Three months preceding intervention
  (referred to as "3 Months Pre" in data analysis);
- Eight weeks of the intervention
  (referred to as "Intervention" in data analysis);
- Three months after the intervention
  (referred to as "3 Months Post" in data analysis);
- A period equivalent to the eight weeks of for the previous year, i.e. intervention June 16th to August 4th, 2016
  (referred to as "2016 Intervention Equivalent" in data analysis).

The periods were counted from a day the intervention started/ended for each group. Therefore, since the two groups received the first and last e-mails on different days, analysis periods reflect that. Specifically, "three months preceding intervention" means the period from March 16th, 2017 to June 15th, 2017 for Group 1; and the period from March 31st, 2017 to June 30th, 2017 for Group 2. "Three months post intervention" refers to the period between July 22nd, 2017 and October 21st, 2017 for Group 1; and to the period between August 5th and November 4th, 2107 for Group 1. Finally, "2016 intervention equivalent" refers to June 16th, 2016 to July 21st, 2016 for Group 1; and June 30th, 2016 to August 4th, 2016 for Group 2. Figure 4 shows the daily number of posts for the four analysis periods.

Table 28
LitterGram analysis periods.

Analysis Period	Label	Group 1	Group 2
Three months preceding the intervention	3 Months Pre	16/03/2017 – 15/06/2017	30/03/2017 – 29/06/2017
Intervention	Intervention	16/06/2017 – 21/07/2017	30/06/2017 – 04/08/2017
Three months after the intervention	3 Months Post	22/07/2017 – 21/10/2017	05/08/2017 – 04/11/2017
2016 intervention equivalent	2016 Equivalent	16/06/2016 – 21/07/2016	30/06/2016 – 04/08/2016

Figure 4
Daily number of LitterGram posts for analyses periods.



I conducted an analysis in which I first looked at trends in LitterGram usage during the different analysis periods. Next, I compared LitterGram usage during the different time periods, by conducting an ANOVA and appropriate post-hoc tests to detect any significant differences.

Two thousand sixteen (2016) intervention equivalent.

LitterGram usage grew during the 2016 intervention equivalent period, that is between June 2016 and August 2016 (see Figure 5 and Table 27). There was an average increase of .51 posts per day (Standardized ß=.514; p=.000). A simple regression conducted to identify the trend showed the model fit the data well ($F_{(1;47)}$= 16.849; p=.000) and it explained 25% of the variance (Adjusted R^2=.248). This positive effect can be attributed to a growing size of the user base, as the number of LitterGram users increased from approximately 3500 to 4500 during the eight-week period.

Three months preceding the intervention.

LitterGram usage was stable during the three months preceding the intervention (Standardized ß=-.125; p=.234; see Figure 6 and Table 28). A simple regression conducted to identify the trend showed the model did not fit the data ($F_{(1;90)}$= 1.347; p=.234; adjusted R^2=.005). This stability in usage was expected, as user base stopped growing and was stable, at around 9500 users, throughout this period.

Intervention period.

LitterGram usage grew during the intervention period and there was an average increase of .48 posts per day (Standardized ß=.482; p=.001; see Figure 7 and Table 29). A simple regression conducted to identify the trend showed the model fit the data well ($F_{(1;47)}$= 13.901; p=.001) and it explained 22% of the variance (Adjusted R^2=.215). This positive effect cannot be attributed to a growing user base as the number of users was stable.

Three months after the intervention.

LitterGram usage decreased in the three months after the intervention, with an average decrease of .60 posts per day (Standardized ß=-.602.; p=.000; see Figure 8 and Table 30). A simple regression conducted to identify the trend showed the model fit the data well ($F_{(1;89)}$= 50.621; p=.000) and it explained 36% of the variance (Adjusted R^2=.355).

Figure 5
2016 equivalent daily posts with a trendline.

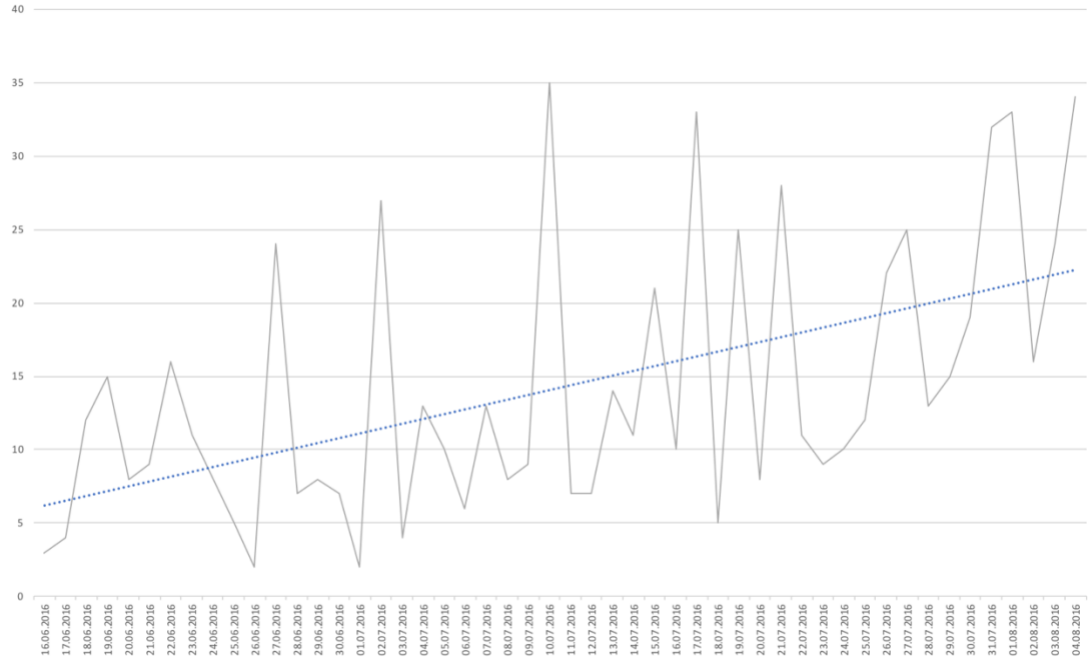


Table 29
2016 intervention equivalent usage trend regression.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.514	.264	.248	8.0842

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1101.145	1	1101.145	16.849	.000
Residual	3071.630	47	65.354		
Total	4172.776	48			

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-24.892	9.624		-2.586	.013
Day	.335	.082	.514	4.105	.000

Figure 6
3 Months Pre daily posts with a trendline.

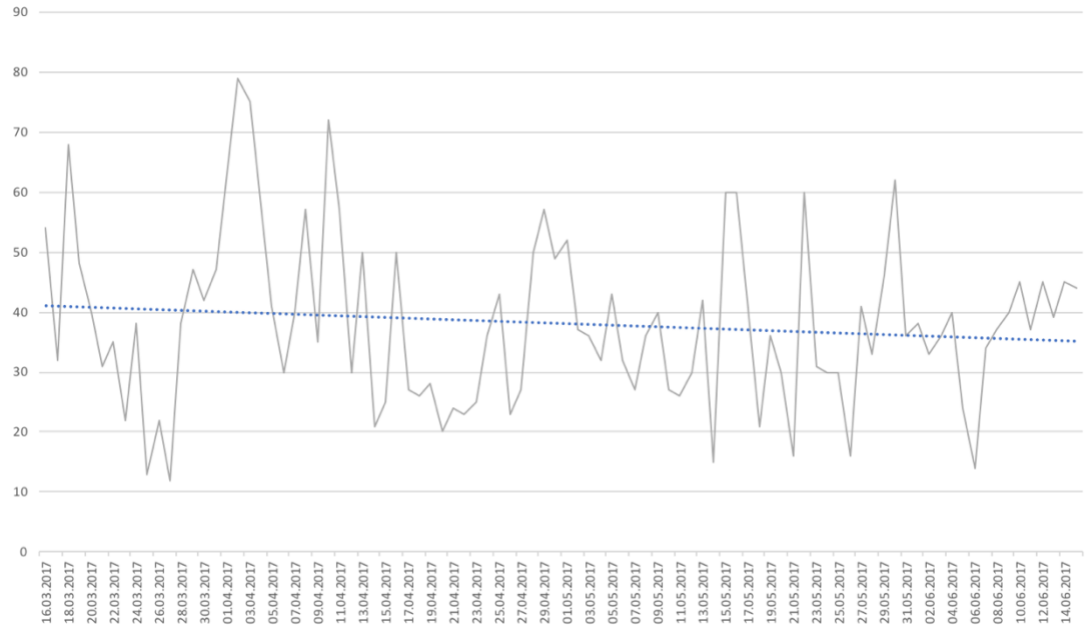


Table 30
3 Months Pre usage trend regression.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.125	.016	.005	14.1983

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	289.766	1	289.766	1.437	.234
Residual	18143.147	90	201.591		
Total	18432.913	91			

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	65.475	22.874		2.862	.005
Day	-.067	.056	-.125	-1.199	.234

Figure 7
Intervention daily posts with a trendline.

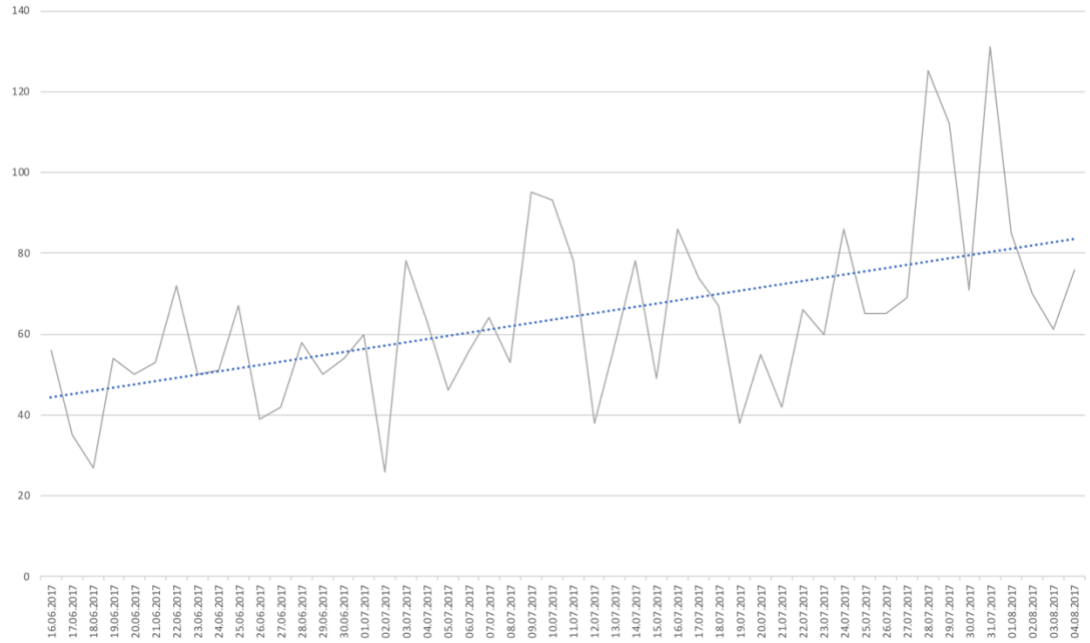


Table 31
Intervention trend regression.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.482	.232	.215	15.7530

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	3449.720	1	3449.720	13.901	.001
Residual	11415.280	46	248.158		
Total	14865.000	47			

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-225.480	76.937		-2.931	.005
Day	.598	.160	.482	3.728	.001

Figure 8
3 Months Post daily posts with a trendline.

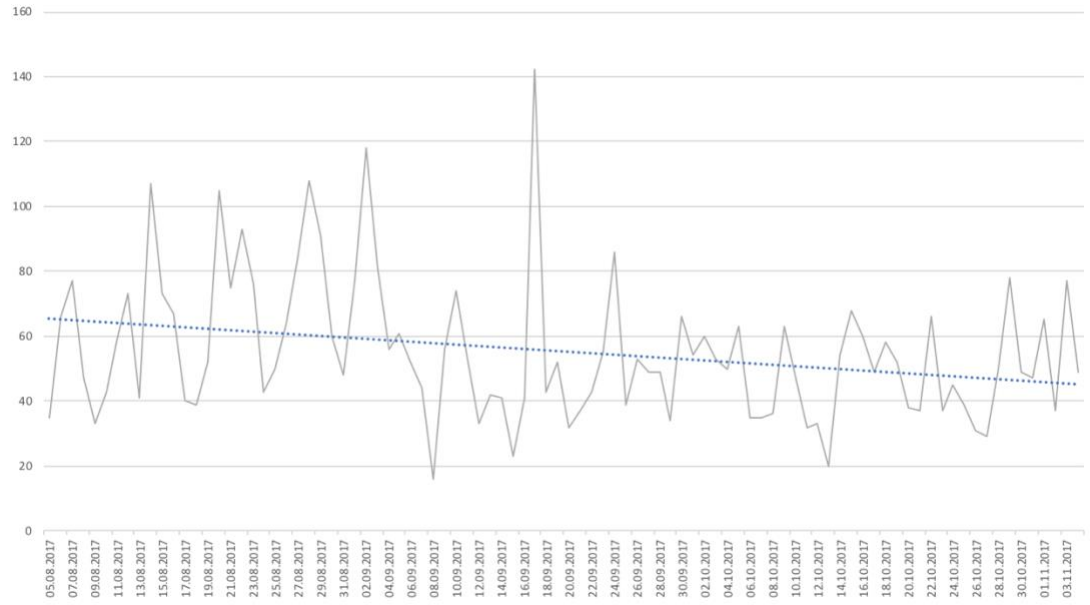


Table 32
3 Months Post trend regression.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.602	.363	.355	18.8934

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	18069,668	1	18069.668	50.621	.000
Residual	31769,519	89	356.961		
Total	49839,187	90			

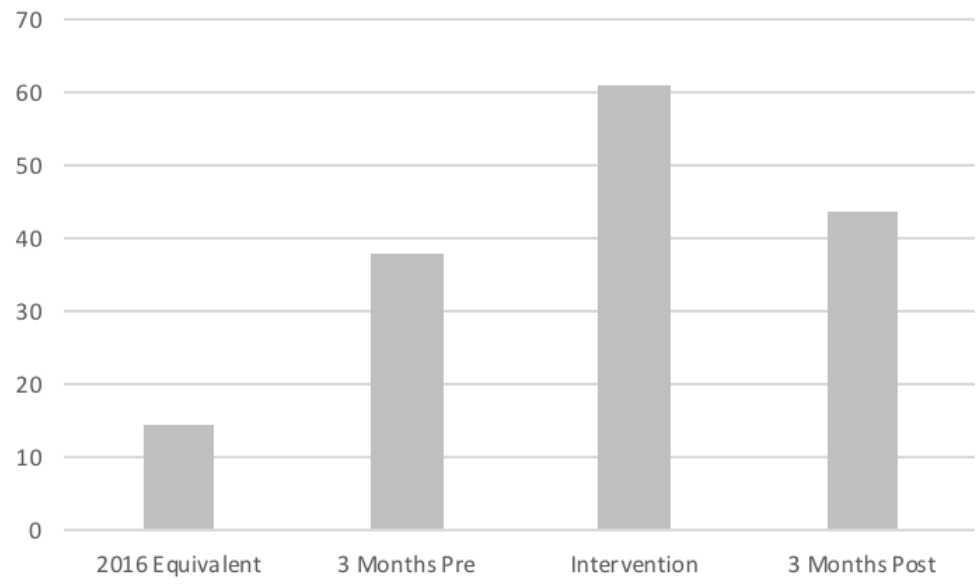
Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	334.818	40.958		8.175	.000
Day	-.528	.074	-.602	-7.115	.000

Trend and usage summary.

Overall, the analyses showed there were different trends in LitterGram usage in the four analysis periods. LitterGram grew in the year preceding the analysis period – the number of users increased and, subsequently, the number of pictures posted was increasing as well. However, in the period leading up to intervention, between March 2017 and the beginning of June 2017, LitterGram user base and usage stabilized and there was no significant difference in the number of pictures posted in this time period. The average number of posts per day for this period was 38.10 (SD=14.23). Next, there was a significant increase in the number of pictures posted during the intervention period, to an average of 61.25 (SD=17.78) pictures per day, followed by a significant decrease, to an average of 43.75 (SD=23.53), in the three months after the intervention. Finally, during the 2016 equivalent to intervention period (16 June 2016 – 4 August 2016) the average number of posts was 14.33 (SD=9.32) although, as was mentioned earlier, the user base was approximately half the size at the time.

Figure 9
Average daily number of LitterGram posts for the four analysis periods.



Intervention Impact

To evaluate whether the differences in usage between the different periods were significant, I conducted an ANOVA. There was a significant effect of an analysis period on the number of pictures posted for the four conditions ($F_{(3,276)}$=58.546, p=.000). Fisher's Least Significant Difference post-hoc analysis showed significant differences between all analysis periods. Specifically, the number of pictures posted during the intervention was significantly higher than in the three months preceding the intervention (Mean difference=23.1413; p=.000; 95% confidence intervals 16.91 to 29.38). The average number of posts during the intervention period was also higher than in the three months after the intervention (Mean difference=17.50; p=.000; 95% confidence intervals 11.26 to 23.75). There was also a significant difference between the average number of pictures posted in the three months before the intervention compared to the three months after the intervention (Mean difference=-5.64 p=.033; 95% confidence intervals -10.82 to -.46). None of these differences can be attributed to changes in the number of LitterGram users, as the user base size was constant at the time.

Table 33
ANOVA comparing the average daily posts in the four analysis periods.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Intervals		Min	Max
					Lower Bound	Upper Bound		
2016 Equivalent	49	14.327	9.3238	1.3320	11.648	17.005	2.0	35.0
Intervention	48	61.250	17.7842	2.5669	56.086	66.414	26.0	112.0
3 Months Pre	92	38.109	14.2323	1.4838	35.161	41.056	12.0	79.0
3 Months Post	91	43.747	23.5323	2.4669	38.846	48.648	1.0	108.0
Total	280	39.746	22.6292	1.3524	37.084	42.409	1.0	112.0

ANOVA

Model	Sum of Sq.	df	Mean Sq.	F	Sig.
Regression	55561.121	3	18520.374	58.546	.000
Residual	87309.875	276	316.340		
Total	142870.996	279			

Table 34
Post-hoc LSD tests.

(I) Analysis Period	(J) Analysis Period	Mean Difference (I – J)	Std. Error	Sig.	95% Confidence Intervals	
					Lower Bound	Upper Bound
2016 Equivalent	Intervention	-46.9235	3.6120	.000	-54.034	-39.813
	3 Months Pre	-23.7822	3.1455	.000	-29.974	-17.590
	3 Months Post	-29.4207	3.1515	.000	-35.625	-23.217
Intervention	2016 Equivalent	46.9235	3.6120	.000	39.813	54.034
	3 Months Pre	23.1413	3.1668	.000	16.907	29.376
	3 Months Post	17.5027	3.1728	.000	11.257	23.749
3 Months Pre	2016 Equivalent	23.7822	3.1455	.000	17.590	29.974
	Intervention	-23.1413	3.1668	.000	-29.376	-16.907
	3 Months Post	-5.6386	2.6296	.033	-10.815	-.462
3 Months Post	2016 Equivalent	29.4207	3.1515	.000	23.217	35.625
	Intervention	-17.5027	3.1728	.000	-23.749	-11.257
	3 Months Pre	5.6386	2.6296	.033	.462	10.815

Addressing Autocorrelation and Seasonality[5]

While the above analysis indicated that the intervention was effective, the results need to be interpreted with caution since LitterGram usage may be seasonal. Moreover, data for subsequent days may have been autocorrelated, i.e. usage on a day could depend on usage on a previous day. Indeed, as a Ljung-Box test showed (see Figure 7 in Appendix D), there was a serial dependency in the residuals, showing significant results for lags up to 20, implying autocorrelation. In such a case, the standard errors of the estimates shown earlier could be biased (Gujarati, 2009).

To determine the order of autocorrelation, residual autocorrelation (ACF) and partial autocorrelation functions (PACF) were plotted (see Figure 8 in Appendix D). ACF describes the correlation between two points at lag *k*, e.g. ACF at lag one is the correlation between two consecutive points in time (e.g day 1 vs. day 2), while ACF at lag two is the correlation between alternate points (e.g. day 1 vs. day 3). These correlations were significant for lags one, nine, 10 and 16.

[5] Analyses presented in this section have been conducted under my direction by Karan Arora, who has been involved in this project as a part of my supervision of his MSc in Behavioural Economics and Science dissertation. The write-up of the results is my own.

Partial autocorrelation functions, on the other hand, are values for a *k*-th lag when an error term of a typical interrupted time series model, which takes the form of $Y_t=\beta_0+\beta_1 T+\beta_2 X_t+\beta_3 T X_t+\varepsilon_t$, is regressed on *k* lagged terms. In other words, it indicates whether, after controlling for previous lags, a *k*-th lag is significant. As the analysis showed, the partial autocorrelation between residuals was significant for lags one, nine and 16, indicating a possible seasonality in data for lags nine and 16.

To address the possible influence of these autocorrelations on the estimation of the effectiveness of the intervention, Autoregressive Integrated Moving Average (ARMIA) modelling was conducted, which takes into account dependency in the dependent variable and in forecast errors. The general formula of ARIMA (p,d,q) is:

$$Y_t = \beta_0 + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{i=1}^{q} \gamma_i \varepsilon_{t-i} + \varepsilon_t$$

where p is the number of lags of dependency in the dependent variable (Y_t); q is the number of lags of dependency in error terms (ε_t ; forecast errors); and d is the order of difference needed to make the series stationary, i.e., so that the mean and variance do not change over time.

Pre-intervention vs. intervention LitterGram activity.

The model was estimated using the Box-Jenkins (1976) approach, as described by Enders (2014). According to this method, before the order of serial dependency is applied, data needs to be made stationary, i.e. the mean, variance and autocorrelation need to be constant over time. Augmented Dickey-Fuller Test (−9.12, $p<0.01$) and a KPSS test (0.053 $p>0.1$) showed LitterGram data was stationary and therefore no differencing was applied.

The next step, according to the Box-Jenkins approach, is to choose the number of lags of dependency in the residuals. AR(1) was selected as appropriate in this case since both the ACF and PACF were significant at lag

one. Moreover, most behavioural data can be explained by AR(1) processes (Hartman et al., 1980).

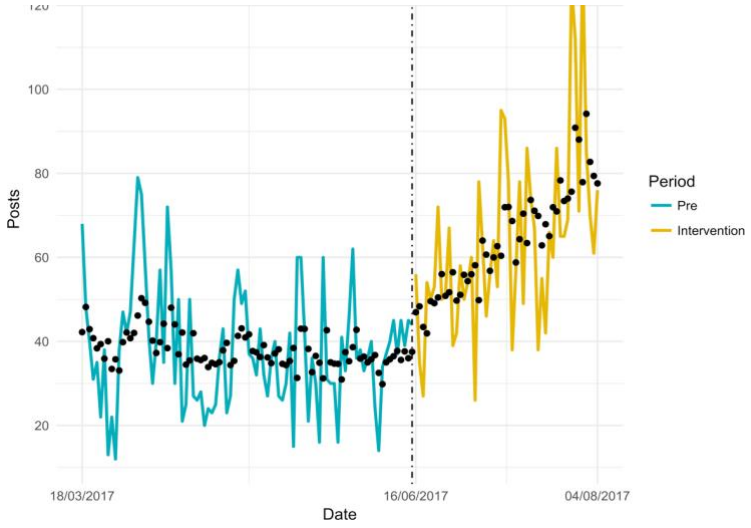
The residual dependency coefficient was significant (p=.000), confirming the need for the use of this modelling technique. On average, the observed error was .261 of the observed error in a previous time period. In line with the previously presented results, there was no significant pre-intervention trend. However, the model showed that during the intervention period there was a significant slope change of .86 (p=.000; 95% confidence intervals .43 to 1.28).

Table 35
ARMIA model comparing 3 Months Pre with Intervention periods.

No of observations	140
AIC	1188.97
BIC	0.480
Residual Std. Error	15.25 (df = 135)

	Number of posts
$\boldsymbol{\rho}$	.26*** (.082)
$\boldsymbol{\beta_1}$	-.07 (.082)
$\boldsymbol{\beta_2}$	8.87 (7.09)
$\boldsymbol{\beta_3}$	.86*** (.21)
$\boldsymbol{\beta_0}$	41.35*** (4.33)

Figure 12
ARIMA model fit (3 Months Pre vs. Intervention).



Additional analysis showed that no further lags were required (see Figures 9 and 10 in Appendix D for an additional Ljung-Box test and ACF/PACF plots), indicating that with the use of this modelling technique the residuals became white noise, as expected in field experiment data. Moreover, the analysis indicated there was still seasonality at lag 16. Adding this to the model did not influence β_2 and β_3 in a significant way, therefore subsequent analyses were conducted using this model.

Intervention vs. post-intervention LitterGram activity.

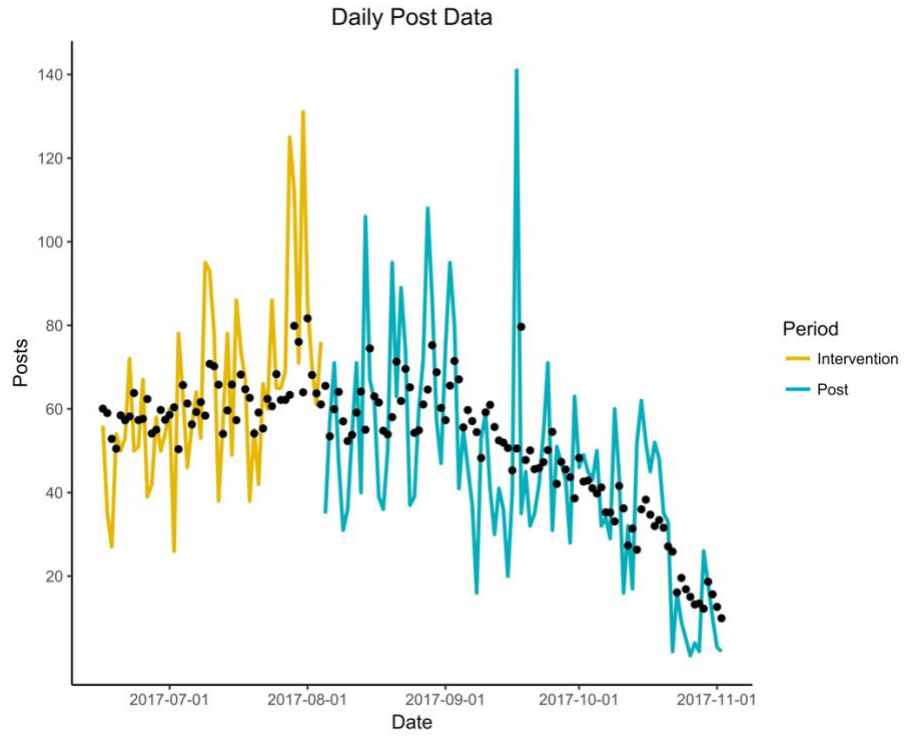
Next, analogous to the approach described earlier, we compared the average number of pictures posted on LitterGram in the three months after the intervention to the intervention period. As previous analyses showed, there indeed was a significant decrease in usage. There was a significant slope change of -1.48 (p=.000; 95% confidence intervals -2.09 to -.85), showing that the inclusion of autocorrelation did not impact the conclusion regarding the effectiveness of the intervention.

Table 36
ARIMA model comparing Intervention and 3 Months Post periods.

No of observations	140
AIC	1245.1
BIC	1262.75
Residual Std. Error	19.85 (df = 135)

	Number of posts
$\boldsymbol{\rho}$	.26*** (.08)
$\boldsymbol{\beta_1}$	.42* (.19)
$\boldsymbol{\beta_2}$	-27.03*** (10.50)
$\boldsymbol{\beta_3}$	-1.48*** (.32)
$\boldsymbol{\beta_0}$	53.45*** (6.09)

Figure 15
ARIMA model fit (Intervention vs. 3 Months Post).



Seasonality.

While all the results demonstrated that LitterGram usage grew in the time of the intervention and then dropped after the intervention ended, what remained unanswered was a question regarding seasonality. It could be that the changes were seasonal, with more people using LitterGram in early summer (mid-June to August, i.e. the intervention period) than in late spring (mid-March to mid-June). To address this question, a trend analysis was conducted, on data from 2016 equivalents of the key analysis periods, i.e. the three months pre-intervention equivalent (16th March to 15th June 2016) and the intervention period (16th June to 4th August 2016).

On average, LitterGram usage grew during the pre-intervention 2016 equivalent period by .318 posts per day, which, as was mentioned earlier, can be explained by a steadily growing in user base. There were no significant changes in usage trend during the intervention equivalent. Since no such increase happened in the previous year, these results indicate that

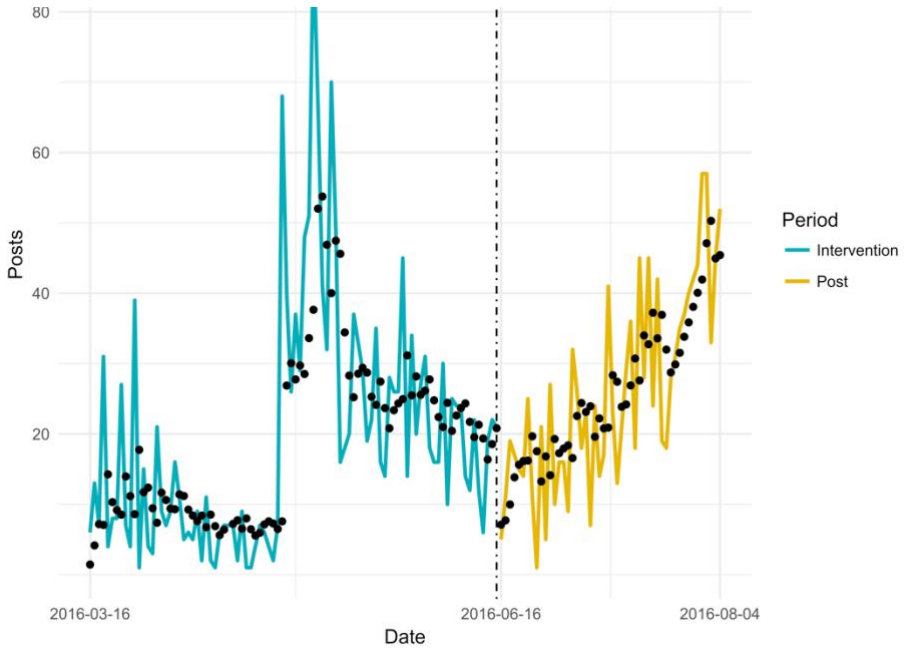
the increase in usage during the intervention was *not* a seasonal occurrence but rather an effect of the intervention itself.

Table 37
ARIMA model comparing 2016 3 Months Pre and 2016 Equivalent periods.

No of observations	141
AIC	1114.53
BIC	1135.17
Residual Std. Error	12.077 (df = 135)

	Number of posts
ρ	.911*** (.050)
β_1	-.606***(.087)
β_2	. 318*** (.094)
β_3	-15.097 (9.765)
β_0	.281 (.366)

Figure 12
ARIMA model fit (2016 3 Months Pre vs. 2016 Equivalent).



Discussion

The main practical objective of this study was to encourage LitterGram users to use the app more. The main theoretical goal was to evaluate the effectiveness of the Behavioural Change Wheel framework in designing effective behaviour change interventions, as well as to showcase if and how one could use a common and practical communication channel such as e-mail newsletters, to deliver behaviour change interventions and to encourage people to behave more pro-socially.

The analysis indicated that the intervention was successful. There was a significant rise in the average daily number of pictures posted on the app during the intervention period (61.25 per day), compared to app usage in the three months preceding the intervention (38.10 per day) and the three months after the intervention ended (43.75 per day). This change cannot be explained by seasonal patterns or changes in user base size.

It is worth noting that, most likely, the intervention had only a short-term impact on behaviour. While there was a significant increase in usage in the 3 Months Post, as compared to 3 Months Pre, looking at the negative trend in usage after the intervention was stopped, one can assume that with time LitterGram activity decreased to its pre-intervention level. The first important comment regarding this fact is that the objective of the intervention was a short-term change, i.e. an increase in usage while e-mails were being sent, not thereafter. The target behaviour was “to post on LitterGram”, not “to post for (e.g.) a year”. In other words, the goal was a short-term change.

Second, the problem of the maintenance of the effect links back to the issue of simplification of behavioural change interventions. While a lack of a long-term change could be a crucial downside in the case of many interventions, I believe it does not reflect poorly on this trial, precisely because of the approach undertaken. Unlike in many other contexts, where an intervention is costly to deliver and can only be sustained over a relatively short period of time, in the case of communication- and e-mail-based interventions as this one, there is no reason why it could not be continued over an extensive period of time or re-introduced on a regular basis in shorter

bursts. Subsequent research should explore optimal intervention intensity and length, which would result in a long-term change, keeping in mind that this changed objective means that a new TDF behavioural diagnosis needs to be conducted.

Another important area for future research related to intervention intensity is the impact on unsubscribe rates. During this intervention, 1561 people, that is 17.19% of the user base, unsubscribed from receiving LitterGram newsletters. This could be interpreted as a good thing from a marketing point of view because it "cleared" the user base of people who were not interested in LitterGram activity, news and updates. However, it could equally be the case that this was a negative consequence of the intervention, as it significantly reduced the number of people LitterGram could regularly be in contact with.

One explanation for the high unsubscribe rate is that the intervention was too intensive – too many e-mails were sent in a relatively short period of time. While the number and frequency of e-mails, as well as the overall duration of the intervention, were consulted with LitterGram, data suggests this may have been the case. Available data did not allow me to conduct analyses that would explore this issue, one reason being that e-mails sent in the four weeks when both groups underwent the intervention were aggregated. This meant that I was not able to verify precisely how many people unsubscribed after receiving each additional e-mail. It would be useful to conduct even such a simple analysis, to verify whether there was a visible increase in unsubscribe rates after an n-th e-mail. If so, a subsequent intervention could be modified accordingly. Ideally, such analysis should be done on an ongoing basis, with the aim of finding an optimal frequency at which e-mails should be sent, yielding the highest number of posts and the lowest number of unsubscribes.

One final interesting aspect of the results is that the positive change in behaviour was achieved despite the fact that TDF diagnosis used intent as the dependent variable rather than actual behaviour. This fact brings one more important question future research, of whether the intervention was effective because it relied on the Behavioural Change Wheel and the specific behavioural change techniques chosen had such a significant impact; or

whether the change was caused by the fact that the e-mails served merely as reminders to use the app more, irrespective of their content. To address this, a control group should be added to the next intervention, which would receive "dummy" e-mails (with content *not* based on the BCW) or, similarly to the design of the Twitter Study 2.2, e-mails that use a BCT that is *not* based on the TDF diagnosis.

Despite leaving some research questions unanswered, this project is the first one, to my knowledge, to apply the Behavioural Change Wheel framework in the field and to report significant results of such an intervention. I was able to increase LitterGram usage by 61% and by doing so to generate social impact in an important domain that is the problem of littering in the United Kingdom.

Moreover, an additional contribution of this work is the design of a methodology of how to apply behavioural change theory to e-mail communication. Since e-mails and newsletters are such a ubiquitous and easy-to-use tool, this method can help more simply apply behavioural science to address not only the problem of litter but a number of other social dilemmas, by diverse public and private institutions, on a mass scale. Additionally, such an approach could result in resources being used more wisely. Each e-mail could be carefully designed, resulting in less unnecessary, unimpactful messages being created, sent and received. Such a methodical approach puts quality over quantity and could, over time, lead to a reduction in the amount of noise generated and spam we all receive into our inboxes and onto our screens every day.

CHAPTER FIVE

Conclusions

The aim of this concluding chapter is to offer a summary of findings and to link these results to the overarching aims of the thesis, as well as to discuss the limitations and practical implications of the studies and to suggest future directions for research.

As part of my doctoral work, I conducted three research projects, in which I applied behavioural science theory and insights to address selected social and intrapersonal dilemmas, through the means of written communication. While unique, the three projects have important commonalities, described in detail in Chapter 1, that ensure the work is coherent and contributes to existing behavioural science theory and practice in a consistent way. The main objective of my work was to contribute, practically and theoretically, to bringing behavioural science – in a simple, practical yet systematic and evidence-based way – outside of the context of public policy, by testing existing frameworks, principles, applying them in real-world contexts; and outlining how one can approach the development of new behavioural change techniques or measurement tools that would be applicable in communication.

It seems that currently the use of evidence-based applied behavioural science to promote cooperation in social and intrapersonal dilemmas is largely restricted to public institutions. That is not to say that other entities, predominantly big corporations, don't use this approach. As behavioural science gains popularity, more companies are establishing their own behavioural science units, BUPA, Barclay's, ING or SwissRe being prime examples. However, the work of those units does not necessarily have the same objectives as set at the beginning of this thesis. Rather than developing new approaches to simplify the application of behavioural science and tackling social and intrapersonal dilemmas, their focus is more of a practical, business-oriented nature. According to information on the companies' corporate websites, the aim is, e.g. to create practical investing applications (Barclay's, n.d.); to use ideas from behavioural economics and social psychology to educate consumers on their "sometimes surprising relationship with money" (ING, n.d.); to improve the understanding of drivers of consumer behaviour to help the company's clients optimise interactions with

their customers (SwissRe; n.d.); or to improve employee engagement and health in the workplace (BUPA, 2015).

The second problem with the current use of behavioural science outside of public policy, possibly related to the issue of confidentiality, is that even if some organisations do use the theory and insights to address important social issues, many do not publish results of such work or what they publish is general and vague, making it impossible to make any conclusions regarding the effectiveness of such work (see e.g. Behavioural Architects, n.d.). This lack of thorough publications means that knowledge is lost, impacting both the theoretical and practical advancement of the field. Not publishing means new insights don't reach as many people, including the vast number of academics interested in this line of work, staggering the growth of the field and progress in solving societal issues. If more detailed information is made publicly available, it is typically in the form of reports (e.g. HubBub, n.d.; Keep Britain Tidy, n.d.) rather than articles in peer-reviewed journals. And without the scrutiny of peer review processes, the way the knowledge is used and applied may be methodologically incorrect, resulting in smaller impact than we could obtain.

Despite the fact that behavioural science is making its way outside of the field of public policy, if we compare the number of organisations that do have behavioural science units with, for example, the number of companies that engage in PR or marketing activities, we will see that the penetration of behavioural science is still low. This not-yet-ubiquitous use of behavioural science is expected if we consider how young this academic discipline is. If we treat the first publications by Kahneman and Tversky (e.g. Kahneman & Tversky, 1973; Tversky & Kahneman, 1973; 1974) as a contractual date when behavioural economics was established and the appointment of the Behavioural Insights Team in 2010 as the first professional and evidence-based attempt at practical application of behavioural science (Halpern, 2016), then we are looking at a field that is just over 40 years old, with its practical application developing for less than a decade.

The second aspect of this problem is the development of frameworks (rather than just interventions aimed at specific problems). For behavioural science to be used more wildly by diverse organisations, there need to be

easy-to-use and reliable frameworks that will guide choice architects through the process of intervention development. The Behavioural Change Wheel is an example of such a framework, yet it is a framework developed with public policy in mind – it lists seven *policy* categories and the authors state that these "[represent] types of decisions made by authorities" (Michie, Atkins & West, 2014; p. 134), clearly implying that the BCW was developed with policy-makers in mind. And while *Communication/Marketing* is one of the seven policy categories and the framework does list modes of delivery for intervention functions that involve communication (p. 177), based on my experience using the BCW, it is not well-adapted to a non-policy context.

Several marketing agencies that specialise in the application of behavioural science in marketing, such as Ogilvy or Behavioural Architects have developed their own frameworks, e.g. Behavioural Architects' *BE Inspired Methodology* (Behavioural Architects, n.d.; Vlaev, personal communication, September 9, 2018) that possibly are just as comprehensive as the BCW, while being simpler and better suited for communication. However, details of these frameworks are not shared or discussed. This should be of no surprise, considering the main goal of these companies is to generate profit (Friedman, 2007) and own frameworks can become a competitive advantage and, subsequently, will be kept confidential.

In short, we are dealing with a new and potentially a very powerful field of work that is only making its way out of public policy and into the world of communication; and in most instances that it is being used, the effects of such work are not being made publicly available. These two facts have important negative consequences that impact our chance to solve social and intrapersonal dilemmas. As was described in Chapters 2 and 4, the gravity and scale of issues at hand here – littering, obesity, non-communicable diseases – has increased in the last decades. For example, childhood obesity in England is currently at over 50% and rising (NHS Digital, 2017), despite diverse behavioural change interventions being implemented in schools (see e.g. Khambalia et al., 2012). Likewise, the amount of beach litter in the UK has been constantly increasing (Marine Conservation Society, 2017; Statista, 2018a), despite governmental attempts at reducing littering, such as the publication of the National Litter Strategy

(HM Government, 2017). These problems are complex and, in order to be solved, they seem to require the engagement of not only public institutions but rather as many organisations and individuals (such as social media influencers) as possible *and* to share the effects of such work – both of individual interventions as well as of new, effective frameworks – so that more entities can adopt this line of work.

Therefore, how do we encourage more non-public organisations to use behavioural science in their attempts to solve important social issues and, then, to publish such results? The first step seems to be the development of behavioural change techniques, frameworks and platforms that can be used in a non-policy context. This is why initiatives such as Nudgeathon – a behavioural change competition in which students and professionals crowdsource solutions to diverse social issues using behavioural science – are of importance and needed (see Connolly at al., 2018). They create opportunities for those *not* familiar with behavioural science and those who don't have influence over policy to tackle social issues in an effective way.

Most importantly, however, we need to develop tools and frameworks, and to gather insights and experience that will allow this knowledge to be more easily used in communication. Communication – whether done on social media, television, in the press, directly, via e-mails or even on packaging – is the main behavioural change tool in this field of work, as discussed in Chapter 1. Then, once evidence- and theory-based interventions are developed and implemented, their results should be published. My research aimed to do just that – to start filling this gap, by apply behavioural science to communication; to outline how to use existing frameworks in communication; to develop new behavioural change insights and measurement tools, and by doing so, to contribute to the development and widespread use of behavioural science outside of public policy; and finally, to publish these results.

One final issue concerning the spreading of behavioural science to as many organisations as possible – private and public – which would result in many more interventions being implemented, relates to how change happens in complex systems. In 1988, Per Bak (Bak, Tang & Wiesenfeld, 1988) put forward a model of self-organised criticality, which is commonly presented

as a metaphor of a sand pile, onto which new grains of sand are added, one by one. The question of concern is when will an avalanche – a significant and visible change in the system – occur. As the model shows, change is not smooth but rather happens catastrophically and somewhat randomly. Large avalanches occur at a rather predictable rate but there is no sure way of knowing which grain of sand will cause it. By adding grains one by one, one makes the system evolve to a critical state until finally a small event – a single grain of sand – causes a chain reaction and an avalanche.

This model has been since adapted across diverse fields, including economics and social sciences (e.g. Anzola, Barbrook-Johnson & Cano, 2017; Turcotte & Rundle, 2012). While self-organised criticality is just a model and a simplification of reality and how change happens, it can be applied to the problem of social and intrapersonal dilemmas and the impact behavioural change interventions may have behaviour. We can see there are two important implications. The first one is that there need to be *very* many grains of sand – behavioural change interventions – for a change to happen. The second is that there is no way of knowing when a significant change – an avalanche – will occur. However, we do know that with time, if new interventions are implemented, a meaningful shift in social norms will take place.

This is why it's so important for a myriad of organisations and institutions to use behavioural science approaches to tackle societal issues; and why, therefore, it is so important for this approach to be extended outside of policy. We need to adapt existing knowledge, to develop new insights and to develop comprehensive frameworks, such as the Behavioural Change Wheel, to be applied in communication. Work described in this thesis is a small step towards this goal.

Summary of Findings

The three research projects – Hidden Consequences, Twitter and LitterGram – were three such attempts at identifying which behavioural science insights and principles, and in what way, could be applied to communication, rather than policy. This is why I in my research,

I (1) relied on communication as the mode of intervention delivery; (2) designed all the interventions according to the highest methodological standards and based them in theory and evidence by applying the leading behavioural change framework; (3) tested the effectiveness of this framework in a non-policy, non-health decision making context; (4) developed a measurement tool that merged online experimental research with social media; (5) attempted to develop several new behavioural change techniques, outlining how one could approach such a task; (6) established a collaboration with a start-up that never used behavioural science in their communication or work before; (7) showcased how one could use e-mails as a common communication channel to deliver behavioural change interventions; and (8) plan on publishing all three chapters in peer-reviewed journals.

Hidden Consequences

The first project (Hidden Consequences, Chapter 2) focused on applying a well-research *hidden zero effect* in a more real-world setting of healthy eating. Specifically, I hypothesised that reminding people of the health consequences of healthy and/or unhealthy foods and drinks would make them more likely to choose the healthier options. Support for this hypothesis was mixed, raising the issue of reproducibility in research, discussed further later in this chapter. Study 1 results supported the hypothesis, showing that, in online experimental setting, respondents who were reminded of the fact that foods and drinks could have an effect on their health were more likely to choose healthy options, regardless of whether these consequences were mentioned for healthy or unhealthy items. However, I was not able to replicate the effect in a follow-up field experiment (Study 2). Neither the mention of the health effect of healthy or unhealthy items had a significant impact on which snack participants chose.

The Behavioural Change Wheel Projects

The second and third projects (Twitter, Chapter 3; LitterGram,

Chapter 4) used the Behavioural Change Wheel framework to develop communication-based interventions aimed at promoting anti-littering behaviours. Keeping in mind the overall objective of simplifying behavioural change work, the behaviours targeted were not littering itself but rather "proxy" behaviours. The goal of the two projects was to encourage two online communities – Prolific Academic and LitterGram users – to actively use Twitter and LitterGram, respectively, to start a conversation about litter online and to exert social pressure on other stakeholders, such as other app users and local councils, to address the problem to litter.

Twitter.

The Twitter study had three main goals. First, I wanted to verify whether the Behavioural Change Wheel framework could be effectively used in the context of environmental (rather than health) decision-making and if it would increase people's willingness to tweet anti-littering messages. Second, I wanted to develop and test two new identity-based interventions, which – if effective – could be added to the BCW framework. Third, it was my goal to develop and test a new way of measuring behaviour in online experiments, through a Qualtrics – Twitter interface.

In Study 1, the intervention that used behavioural change techniques related to the *Goals* domain was effective in changing people's intent to tweet anti-littering messages, which was the main objective of the study. However, none of the interventions targeting the *Social and professional role and identity* domain, which I developed, had a significant effect. I was also unable to change actual behaviour. In Study 2, the BCW-based intervention had a significant impact on behaviour and was more effective in increasing the likelihood to tweet than an intuition-based intervention that used a social norms message. Overall, the results of this study show that the Behavioural Change Wheel can be an effective framework for the development of communication-based interventions and in the context of environmental, rather than health, decision-making. Moreover, with the few improvements made after Study 1, the Qualtrics – Twitter interface proved to be an effective tool in measuring real behaviour in a simple way, rather than having to rely

on intentions, having to set up field interventions or laboratory experiments, which measure behaviour in a more artificial setting, to observe how study participants would behave.

LitterGram.

The main objective of the LitterGram study was to develop a behavioural change intervention, using the BCW framework, to encourage LitterGram users to post more pictures. The intervention was effective. There was a significant increase in the average daily number of pictures posted during the intervention period. In the three months preceding the intervention, the average number of posts per day was 38.10 and it significantly increased, to 61.25, during the intervention period. Overall, just like in the case of the Twitter study, the results of this intervention show that BCW-derived interventions can generate a visible behavioural change. Moreover, these results confirm that the methodology of applying the BCW to e-mail-based newsletters I developed is solid and can be used in subsequent studies.

Implications

These studies have practical implications, not least because they took place in real-world environments and addressed important social problems such as littering and obesity. I draw out four main aspects: applying behavioural science theory to communication design; broadening the portfolio of tools and behavioural change techniques used; merging experimental research with social media and online activity; and using the findings to reshape the broader approach to selection and design of behavioural change research.

Applying Behavioural Science Theory to Communication Design

The main theme of this work, as outlined in Chapter 1, was simplification. Simplification understood as a change in how we approach the application of behavioural science and the development of interventions, with the aim of making behavioural science theory, insights and principles more easily accessible and widely used, to increase cooperation in social and intrapersonal dilemmas and to improve the overall well-being of different societies. Specifically, this simplification relates to resources – time, money, human – required to develop, implement and evaluate the impact of interventions.

By simplifying interventions, we allow more entities, most importantly those from outside of academia or public policy to use behavioural science theory and insights more often and in a more consistent, methodical way. This, in turn, should result in more interventions being developed in general, as well as an increase in the quality, reliability and validity of the work, creating more opportunities for positive change to happen in important areas of our lives, such as environmental protection or health and longevity.

As I demonstrated in my studies, theory and existing frameworks, such as the Behavioural Change Wheel, can be effectively used to influence both behaviour and intent through the use of communication only, even though the BCW was developed with policy and health decision-making in mind. Moreover, even small changes to routine communication, such as e-mail newsletters, can result in a visible social impact, as was the case in my collaboration with LitterGram. Choice architects should, therefore, focus on incorporating behavioural science approaches to communication design to find new ways of increasing cooperation in social and intrapersonal dilemmas, in an efficient and cost-effective way. The results of my studies, most notably of Hidden Consequences, show that desired or undesired behaviour may rest on what word or phrase is selected – in other words, how communication is designed. Behavioural science offers a useful framework for advising how to approach such a design to maximise social impact.

Looking for New Behavioural Change Techniques

One decision that needs to be made before any intervention is developed is what behavioural change technique(s) to use. The Behavioural Change Wheel lists almost 100 such BCTs yet, as my experience of working with this framework has shown, only some of them were easily applicable to any given context. For example, in the case of Twitter, I was only able to use those BCTs that could be used in writing and did not require a specific timing or an interaction or multiple contacts with research participants. This significantly narrowed down the number of available techniques.

Meanwhile, there is a great amount of knowledge and a great number of insights readily available in research already done, which can be used to develop *new* BCTs, including ones designed with communication specifically in mind. An example is my approach to the Hidden Consequences study, in which I took an existing principle – the *hidden zero effect* – and modified it to suit a real-world problem of unhealthy eating. Or my attempt to develop two new BCTs in the Twitter study. While small, this advancement shows how new communication-specific techniques and approaches can be developed,
to help advance behavioural science and to make it more readily available for the entities who may want to use this approach in their pro-social work,
yet lack the resources or knowledge to design more complex approaches.

Merging Online Research with Social Media

An important aspect of simplification and application of behavioural change theory is the measurement of impact. Indeed, in some cases, such as littering, measurement can often be the most challenging piece of intervention design. At the same time, nowadays a big part of our lives happens online – on social media, smartphones and smartphone apps. Data shows that a typical person in the UK spends close to three hours (2 hrs 53 mins) per day on social media and an additional 2 hrs 15 mins

browsing or shopping on the internet. These times are even higher for the younger generation, with 15 to 34-year-olds spending, on average, 3 hrs 38 mins a day on social media and an additional 2 hrs 23 mins on the internet, for a total of over six hours per day (Incorporated by Royal Charter, 2017). Likewise, adults in the UK spent close to two hours a day on their smartphones in 2017 and will spend a prognosed 2 hrs 14 mins in 2019 (eMarketer, 2017).

If close to 40% of our waking hours are spent on social media, why not take this opportunity to merge this important part of our lives with academic research? Platforms such as Prolific Academic allow researchers to study human behaviour online yet, to my knowledge, the majority of this work is restricted to the platforms alone. But, there are relatively easy ways of merging this online research with social media. One such approach, the Qualtrics – Twitter interface, was described in Chapter 3. It allows researchers not only to measure *real* behaviour, rather than declarations and intentions but also to measure it easily. Rather than having to collaborate with local councils or hiring dozens of people to monitor parks and measure changes in the amount of litter dropped (as has been done, for example, in a recent campaign in Leamington Spa conducted by Clean Up Britain; see Clean Up Britain, 2018), we can – in some instances at least – select "proxy" behaviours and, by simplifying interventions in this way, implement more with less resources.

Collaboration Outside of Policy

The final key implication of this work is the issue of establishing collaboration with non-policy-makers that do work in the (broadly understood) field of social responsibility (Dahlsrud, 2008), *and* collaborating with such entities in a way that is evidence- and theory-based, as well as publishing the results of such work. As discussed earlier, it is possible that behavioural science is more commonly used outside of academia and policy than it may seem based on the number of publications, yet since results of such work are published as frequently, this potentially staggers the progress of the field, as well as the chances of effectively addressing social issues.

While the LitterGram study showed it was not easy to design an impeccable intervention in a real-world setting, it was possible to design an *effective* intervention nonetheless. One such approach has been described in Chapter 4 in which I developed and outlined a method of applying behavioural science theory, through the means of the Behavioural Change Wheel, to e-mail-based communication. This approach can be adapted to other forms of written communication – text messages and social media communication, among others – and used by anyone willing to have a positive social impact.

Limitations

As noted in respective the chapters, there were some limitations to the studies presented in this thesis. Below, I provide an overview of these limitations, organising them by those relating to sample, intervention design and outcomes.

Sample

While each of the studies was conducted on a large sample, far exceeding the requirements for quantitative analysis, some limitations regarding the samples used need to be acknowledged. First, in the field experiment conducted at Warwick Business School as a part of the Hidden Consequences project (Study 2 in Chapter 2), a possible problem with the sample was its cultural and, subsequently, linguistic diversity. Since a big part of WBS's students are non-native English speakers, it is very likely that the inability to detect an effect was a result of the fact that people read the instructions *not* in their native languages. Indeed, as previous research suggests, thinking in a foreign language – in this case, English – tends to reduce decision biases (Keysar, Hayakawa & An, 2012).

The Twitter study was conducted as if it were a real-world intervention and, in many respects, it was – most notably because people were asked to use their personal Twitter accounts, i.e. the dependent variable measure was

a real-world behavioural measure. However, the selection of sample for this study did not resemble a real field intervention. Participants were recruited through Prolific Academic and were paid for their participation in the study. While it was made it clear to participants that tweeting messages written as a part of the study was optional, some people may have felt pressured to tweet nonetheless; or the opposite might have been the case – they may have been more reluctant to tweet *because* the study was done through Prolific Academic. While I did not measure this possible control variable, it is worth remembering that this study was only a quasi-field intervention because of how the sample was selected.

Finally, we know very little about LitterGram users. No control variables were measured, as users were anonymous. It is possible that the measurement of aspects such as age or gender would help us draw better conclusions as to whom to target to make the intervention even more effective. Moreover, I measured the impact of the intervention as a whole, while it is possible there were behavioural differences between people who opened the e-mails and those who didn't. This means I cannot rule out the possibility that people who opened intervention e-mails may have been more sensitive to the intervention than those who did not.

Overall, these issues highlight the importance of sample selection and homo- and heterogeneity on study outcome. It hasn't been until recently that the impact of individual and cultural differences on behavioural change have started being explored in more depth (see e.g. Henrich et al., 2005; Levinson & Peng, 2007; Oosterbeck et al., 2004) and to this day, most interventions (such as those conducted by the Behavioural Insights Team, referenced throughout this thesis) aim to find ways of influencing behaviours of societies as a whole, not sub-groups identified based on cultural or psychological qualities.

Intervention Design

Like many field studies, all three projects had some methodological faults. The main limitation of the Hidden Consequences studies, especially of Study 2 was the selection of the healthy-unhealthy pairs. Because the

snacks chosen for this study needed to be portable and relatively cheap, it wasn't possible to use one or several of the food/drink pairs that showed the biggest effect in Study 1. The selection of either a piece of fruit or a cookie could possibly partially explain my inability to replicate the results of Study 1 in Study 2. Indeed, the impact of the intervention on the pairs used in Study 1 differed, implying that the likelihood to choose healthier alternatives may depend on the type of foods and drinks a person is choosing between — an issue that should be explored in subsequent research.

Because the Twitter study was done through Prolific Academic, there were limitations regarding the behavioural change techniques I was able to use. For example, it wasn't possible to send timed reminders to tweet to study participants, who (in Study 2) were asked to tweet at least three anti-littering messages over the course of the following seven days.

Finally, while the LitterGram study was designed with great care, some obstacles and oversights were present. Most notably, the e-mails were sent too frequently, making it impossible to analyse the effect of each individual behavioural change technique/e-mail; there may have been too many e-mails in the intervention overall, considering the number of people who unsubscribed from receiving the newsletters; and not all data was properly recorded.

Overall, while all the limitations relating to the design and methodology of the three studies do not take away from the impact and contribution of this work, they do show just how important careful planning in behavioural science research is. As we know, small changes can have a big impact on human behaviour (Martin, Goldstein & Cialdini, 2014) and small changes – planned or unplanned – in research design can turn an amazing intervention into an ineffective one, or a mediocre intervention into a good one, as the small changes made in the Twitter study and to the Qualtrics – Twitter interface showed. These learnings highlight an important issue of reproducibility and the prospect of developing universal behavioural change frameworks and techniques.

Outcomes

Central to the issues of outcome validity is the aforementioned matter of reproducibility and how context-dependent behavioural change interventions can be. The fact that an intervention worked in one domain, place or at one time does not mean it will necessarily work in another (see e.g. Behavioural Insights Team, 2016b; Open Science Collaboration, 2015). Ineffective approaches are being used, while successful attempts can be difficult to duplicate, are underused or their mechanisms aren't well understood (Michie & Johnston, 2012; Open Science Collaboration, 2015). Moreover, evidence about efficiency is accumulating slowly because interventions tend to be complicated (Craig et al., 2008; Michie & Johnston, 2012).

The problem of reproducibility is most visible in the Hidden Consequences study, in which I wasn't able to replicate the results of Study 1 in the field experiment. This only confirms the importance of testing solutions before they are implemented and testing them in exactly the same context they are going to be rolled out on a mass scale. Some guidelines as to how to approach such planning were discussed in more detail in Chapter 2.

Directions for Future Research

Considering both the implications and the limitations of my work, some clear directions regarding future research emerge. Twenty years ago, Andreoni, Erard and Feinstein (1998) said that "many of the most important behavioural hypotheses and policy questions [are] yet to be adequately investigated" (p.836). While they said it in the context of tax compliance, this statement seems to apply just as well to other areas of human behaviour and behavioural change research, including littering and obesity. Although the use of randomised control trials and behavioural change interventions is rapidly growing, there are many questions still to be addressed in the field.

Who Intervenes on Whom

There are two important aspects that need to be addressed while thinking about the development of the field. The first one is *who* uses behavioural science to implement interventions, the second being who is the target audience of those interventions. The former issue has been discussed in detail in Chapter 1, as well as earlier in this chapter, with a clear direction for future research: to collaborate more with non-public entities – with start-ups, NGOs, social good companies or even individuals, such as social media influencers – to broaden the reach of behavioural science and social impact.

On the other end of this spectrum is the question of *who the intervention targets* – individuals or organisations. To date, the greatest theoretical and empirical advancement has been made in regard to nudging individuals (Alm & McClellan, 2012). Yet, when we look at data, we can see that only 8.3% of waste is generated by households, while the remaining 91.7% is generated by industry, most notably construction (34.7%), mining and quarrying (28.2%) and manufacturing (10.2%; Eurostat, 2014). Likewise, food manufacturers, who decide what goes into the food and drinks we buy in stores, have a huge impact on the level of our sugar and processed foods intake. Twenty-five percent of sugar consumption in the UK comes from non-alcoholic drinks, 20% from baked goods, 11% from alcoholic drinks, 6% from dairy products and 5% from savoury food such as ketchup or salad cream (NHS, 2016). And while some of these products cannot be produced without sugar, it is easy to imagine that even a slight decrease in sugar content, which is plausible if we consider the fact that low-sugar products and sugar-free ketchup *do* exist, could have a significant impact on the overall sugar consumption of a nation. It is important to not only encourage and nudge people to eat less sugar or litter less but to also target the business sector to do their part in solving these dilemmas. Future research, therefore, should focus on identifying differences in the impact of different behavioural change techniques and approaches have on the two groups; and identifying the most effective means of generating change.

Consequently, it would be also advisable to develop a more systematic approach relating to the selection of the target audience. If most waste is produced by the industry, it follows that most interventions should target the industry too, if we want to see the biggest change. However, based on the literature review conducted as a part of this thesis, it seems that it is individuals who are the main focus of interventions, not the industry.

Theories into Frameworks into Tools

The unquestionable strength of the Behavioural Change Wheel is its complexity and comprehensiveness. As discussed in Chapter 2, it compiles almost 20 different frameworks and close to a hundred different psychological theories, into one practical tool for policy-makers. Yet, the BCW has limitations. One is its diagnostic part – the theoretical domains framework – which relies heavily on people's declarations. One key lesson behavioural science has taught us is that many of our everyday decisions are automatic and subconscious (Bargh & Chartrand, 1999; Bargh & Morsella, 2008). If so, then we need to develop ways of diagnosing barriers to behavioural change that tap into the unconscious processes and do not rely only on declarations as these can lead astray.

Secondly, the BCW was developed with health decision-making and policy in mind (Michie et al., 2005). While Twitter and LitterGram studies showed the framework can be effectively used in the context of environmental behaviours and in communication, based on my experience, it is not an optimal tool. There is a need to take existing theories and insights and to turn them into frameworks and specific ready-to-use tools, which entities operating in the private sectors can readily use. Such work entails not only developing a more suitable comprehensive framework but also identifying specific behavioural change techniques – not only those already listed in the BCW but also those that have so far only been explored in more theoretical/abstract experimental settings and have yet to be applied in a real-world context, as was the case with the *hidden zero effect*.

Overall, there is a need to organise existing knowledge in a way that makes it more easily applicable outside of policy and more commonly used by

non-academics and non-policy-makers. While my work attempted to take on such approach and to take a step forward in the right direction, it was not methodical enough. Ideally, research undertaken in the next years should lead us to the development of a comprehensive framework, which would include a list of specific, ready-to-use behavioural change techniques; a framework that could be used by those without an extensive academic background. This way, we would work out a compromise between the theoretical and methodological rigour of academic research and ease of use, scale and simplicity so common in the world of social marketing and practice. We then need to understand if and how the findings of such research feed back into everyday practices and whether this work has a visible impact on the reduction of littering, unhealthy eating habits, and the other social and intrapersonal dilemmas we are currently facing.

REFERENCES

Abel, M. L., Lee, K., Loglisci, R., Righter, A., Hipper, T. J., & Cheskin, L. J. (2015). Consumer understanding of calorie labeling: A healthy monday e-mail and text message intervention. *Health Promotion Practice*, *16*(2), 236-243.

Abraham, C., Kelly, M. P., West, R., & Michie, S. (2009). The UK National Institute for Health and Clinical Excellence public health guidance on behaviour change: a brief introduction. *Psychology, Health & Medicine*, *14*(1), 1-8.

Adams, J., & Nettle, D. (2009). Time perspective, personality and smoking, body mass, and physical activity: An empirical study. *British journal of health psychology*, *14*(1), 83-105.

Adams, J., & White, M. (2009). Time perspective in socioeconomic inequalities in smoking and body mass index. *Health Psychology*, *28*(1), 83.

Ajzen, I. (1991). The theory of planned behavior. *Orgnizational Behavior and Human Decision Processes*, *50*, 179–211.

Ajzen, I. (1985). From intentions to action: A theory of planned behavior. In J. Kuhl & J. Beckmann (Eds.), *Action-control: From cognition to behavior* (pp. 11–39). New York: Springer.

Ajzen, I., & Madden, T. J. (1986). Prediction of goal-directed behavior: Attitudes, intentions and perceived behavioral control. *Journal of Personality and Social Psychology, 22*, 453–474.

Albarracín, D., Gillette, J. C., Earl, A. N., Glasman, L. R., Durantini, M. R., & Ho, M. H. (2005). A test of major assumptions about behavior change: a comprehensive look at the effects of passive and active HIV-prevention interventions since the beginning of the epidemic. *Psychological Bulletin, 131*(6), 856-897.

Alm, J. & McClellan, C. (2012). Tax morale and tax compliance from the firm's perspective. *Kyklos, 65,* 1-17.

Allcott, H., & Gentzkow, M. (2017). Social media and fake news in the 2016 election. *Journal of Economic Perspectives*, *31*(2), 211-36.

Almeida, F. A., You, W., Harden, S. M., Blackman, K. C., Davy, B. M., Glasgow, R. E., ... & Zoellner, J. M. (2015). Effectiveness of a worksite-based weight

loss randomized controlled trial: The worksite study. *Obesity*, *23*(4), 737-745.

Amemori, M., Korhonen, T., Michie, S., Murtomaa, H., & Kinnunen, T. H. (2013). Implementation of tobacco use cessation counseling among oral health professionals in Finland. *Journal of Public Health Dentistry*, *73*(3), 230-236.

Andersson, G., & Kaldo, V. (2004). Internet-based cognitive behavioral therapy for tinnitus. *Journal of Clinical Psychology*, *60*(2), 171–178.

Andreoni, J., Erard, B., & Feinstein, J. (1998). Tax compliance. *Journal of Economic Literature, 36*, 818-860.

Anzola, D., Barbrook-Johnson, P. & Cano, J. (2017). Self-organization and social science. *Computational and Mathematical Organization Theory,23*(2), 221-257.

Apanovitch, A.M., McCarthy, D., & Salovey, P. (2003). Using message framing to motivate HIV testing among low-income, ethnic minority women. *Health Psychology, 22*,60–67.

Ariely, D. (2009). *Predictably Irrational*. New York: HarperCollins.

Auld, M. L., & Johnston, L. M. (2018). A touchy topic: Tactile assessment among pediatric therapists. *Disability and Rehabilitation*, *40*(3), 267-276.

Australian Public Service Commission. (2013). *State of the Service 2012-13*. Canberra, Australian Public Service Commission.

Ayakaka, I., Ackerman, S., Ggita, J. M., Kajubi, P., Dowdy, D., Haberer, J. E., ... & Katamba, A. (2017). Identifying barriers to and facilitators of tuberculosis contact investigation in Kampala, Uganda: a behavioural approach. *Implementation Science*, *12*(1), 33.

Bak, P., Tang, C., & Wiesenfeld, K. (1988). Self-organized criticality. *Physical review A*, *38*(1), 364.

Bargh, J. A., & Chartrand, T. L. (1999). The unbearable automaticity of being. *American Psychologist*, *54*(7), 462.

Bargh, J. A., & Morsella, E. (2008). The unconscious mind. *Perspectives on psychological science*, *3*(1), 73-79.

Barker, F., Atkins, L., & de Lusignan, S. (2016). Applying the COM-B behaviour model and behaviour change wheel to develop an intervention to improve hearing-aid use in adult auditory rehabilitation. *International Journal of Audiology*, *55*(sup3), S90-S98.

Barclay's (n.d). *Behavioural Finance*. Retrieved from https://wealth.barclays.com/en_gb/home/research/research-centre/white-papers/Behavioural-Finance.html

Banks, S.M., Salovey, P., Greener, S., & Rothman, A.J. (1995). The effects of message framing on mammography utilization. *Health Psychology, 14*, 178–184.

Beenstock, J., Sniehotta, F. F., White, M., Bell, R., Milne, E. M., & Araujo-Soares, V. (2012). What helps and hinders midwives in engaging with pregnant women about stopping smoking? A cross-sectional survey of perceived implementation difficulties among midwives in the North East of England. *Implementation Science*, *7*(1), 36.

Behavioural Architects (n.d.) *Case studies*. Retrieved from https://www.thebearchitects.com/case-studies/

Behavioural Insights Team (2014a). *Test, learn, adapt: Developing public policy with randomised controlled trials*. London. Retrieved from http://www.behaviouralinsights.co.uk/publications/test-learn-adapt-developing-public-policy-with-randomised-controlled-trials/

Behavioural Insights Team (2014b). EAST: Four simple ways to apply behavioural insights. London.

Behavioural Insights Team (2016a*). Applying behavioural insights: Simple ways to improve health outcomes.* Report of the WISH Behavioural Insights Forum 2016. Retrieved from http://38r8om2xjhhl25mw24492dir.wpengine.netdna-cdn.com/wp-content/uploads/2016/11/WISH-2016_Behavioral_Insights_Report.pdf

Behavioural Insights Team (2016b). *Update Report 2015-2016*. London.

Behavioural Insights Team (2017). *Update Report 2016-2017*. London.

Bessi, A., & Ferrara, E. (2016). Social bots distort the 2016 US Presidential election online discussion. Retrieved from http://firstmonday.org/article/view/7090/5653

Bickel, W. K., Jarmolowicz, D. P., Mueller, E. T., Koffarnus, M. N., and Gatchalian, K. M. (2012). Excessive discounting of delayed reinforcers as a trans-disease process contributing to addiction and other disease-related vulnerabilities: emerging evidence. *Pharmacology and Therapeutics, 134,* 287–297.

Blake, H., Suggs, L. S., Coman, E., Aguirre, L., & Batt, M. E. (2017). §. *American Journal of Health Promotion*, *31*(2), 109-118.

Block, G., Sternfeld, B., Block, C. H., Block, T. J., Norris, J., Hopkins, D., … Clancy, H. A. (2008). Development of alive! (A lifestyle intervention via email), and its effect on health-related quality of life, presenteeism, and other behavioral outcomes: Randomized controlled trial. *Journal of Medical Internet Research*, *10*(4), 1–18.

Bond, R. M., Fariss, C. J., Jones, J. J., Kramer, A. D., Marlow, C., Settle, J. E., & Fowler, J. H. (2012). A 61-million-person experiment in social influence and political mobilization. *Nature*, *489*(7415), 295.

Bonetti, D. L., Clarkson, J. E., Elouafkaoui, P., Stirling, D. A., Young, L., & Templeton, A. R. (2014). Managing patients on bisphosphonates: The practice of primary care dentists before and after the publication of national guidance. *British Dental Journal*, *217*(12), E25.

Box, G. E., & Jenkins, G. M. (1976). *Time series analysis: forecasting and control, revised ed*. Holden-Day.

Bradley, S. L., Tieman, J. J., Woodman, R. J., & Phillips, P. A. (2017). Which online format is most effective for assisting Baby Boomers to complete advance directives? A randomised controlled trial of email prompting versus online education module. *BMC Palliative Care*, *16*(1), 43.

Brendryen, H., Johansen, A., Duckert, F., & Nesvåg, S. (2017). A pilot randomized controlled trial of an Internet-based alcohol intervention in a workplace setting. *International Journal of Behavioral Medicine*, *24*(5), 768-777.

Bryan, C. J., Adams, G. S., & Monin, B. (2013). When cheating would make you a cheater: Implicating the self prevents unethical behavior. *Journal of Experimental Psychology: General*, *142*(4), 1001–1005.

Bryan, C. J., Master, A., & Walton, G. M. (2014). "Helping" versus "being a helper": Invoking the self to increase helping in young children. *Child Development*, *85*(5), 1–7.

Bryan, C. J., Walton, G. M., Rogers, T., Dweck, C. S., Bryan, C. J., Walton, G. M., … Dweck, C. S. (2011). Motivating voter turnout by invoking the self. *Proceedings of the National Academy of Sciences*, *108*(31), 12653–12656.

BUPA (2015). *Health: Our business. Studies in behaviour change to improve the health of the world*. Retrieved from

https://www.bupa.com/~/media/files/site-specific-files/our%20purpose/workplaces/bupa_health-our-business_vf.pdf

Cadogan, S. L., McHugh, S. M., Bradley, C. P., Browne, J. P., & Cahill, M. R. (2015). General practitioner views on the determinants of test ordering: a theory-based qualitative approach to the development of an intervention to improve immunoglobulin requests in primary care. *Implementation Science*, *11*(1), 102.

Cadogan, C. A., Ryan, C., Francis, J. J., Gormley, G. J., Passmore, P., Kerse, N., & Hughes, C. M. (2016a). Development of an intervention to improve appropriate polypharmacy in older people in primary care using a theory-based method. *BMC Health Services Research*, *16*(1), 661.

Cane, J., O'Connor, D., & Michie, S. (2012). Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implementation Science*, *7*(1), 37.

Carrico, A. R., & Riemer, M. (2011). Motivating energy conservation in the workplace: An evaluation of the use of group-level feedback and peer education. *Journal of Environmental Psychology*, *31*(1), 1–13.

Chambliss, H. O., Huber, R. C., Finley, C. E., McDoniel, S. O., Kitzman-Ulrich, H., & Wilkinson, W. J. (2011). Computerized self-monitoring and technology-assisted feedback for weight loss with and without an enhanced behavioral component. *Patient Education and Counseling*, *85*(3), 375-382.

Chatterjee, S., Rai, D., & Heath, T. B. (2016). Tradeoff between time and money: The asymmetric consideration of opportunity costs. *Journal of Business Research*, *69*(7), 2560-2566.

Cherubini, P., Rumiati, R., Rossi, D., Nigro, F., & Calabro, A. (2005). Improving attitudes toward prostate examinations by loss-framed appeals. *Journal of Applied Social Psychology, 35,* 732–744.

Cialdini, R. B., Demaine, L. J., Sagarin, B. J., Barrett, D. W., Rhoads, K., & Winter, P. L. (2006). Managing social norms for persuasive impact. *Social influence*, *1*(1), 3-15.

Cialdini, R. B., Reno, R. R., & Kallgren, C. A. (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. Journal of Personality and Social Psychology, 58(6), 1015–1026.

Clark, R. E., McArthur, C., Papaioannou, A., Cheung, A. M., Laprade, J., Lee, L., ... & Giangregorio, L. M. (2017). "I do not have time. Is there a handout I can use?": Combining physicians' needs and behavior change theory to put physical activity evidence into practice. *Osteoporosis International*, *28*(6), 1953-1963.

Clean Up Britain. (2018). *Now or never: Leamington Spa* Retrieved from https://www.itsnowornever .org.uk/about/

Connell, L. A., McMahon, N. E., Redfern, J., Watkins, C. L., & Eng, J. J. (2015). Development of a behaviour change intervention to increase upper limb exercise in stroke rehabilitation. *Implementation Science*, *10*(1), 34.

Connolly, D., Dangazele, N., Elmes, D., Kolodko, J., Read, D. & Taj, U. (2018). Using *crowdsourcing and behavioural science to solve important social issues: A Nudgethon approach*. Unpublished manuscript.

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Petticrew, M. (2008). Developing and evaluating complex interventions: The new Medical Research Council guidance. *BMJ*, *337*, a1655.

Curtis, K., Van, C., Lam, M., Asha, S., Unsworth, A., Clements, A., & Atkins, L. (2017). Implementation evaluation and refinement of an intervention to improve blunt chest injury management—A mixed-methods study. *Journal of Clinical Nursing*, *26*(23–24), 4506–4518.

Dahlsrud, A. (2008). How corporate social responsibility is defined: an analysis of 37 definitions. *Corporate Social Responsibility and Environmental Management*, *15*(1), 1-13.

Dawes, R. (1980). Social dilemmas. *Annual Review of Psychology, 31*, 169–93.

DEFRA (2013a, Apr 1). Code of practice on litter and refuse. Retrieved from https://www.gov.uk/government/publications/code-of-practice-on-litter-and-refuse

DEFRA (2013b). Local Environmental Quality: Valuing the neighborhood in which we live. August 2013. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/ attachment_data/file/226561/pb14015-valuing-local-environment.pdf

Dennis, L., & Horn, E. (2014). The effects of professional development on preschool teachers' instructional behaviours during storybook reading. *Early Child Development and Care*, *184*(8), 1160-1177.

Dolan, P., Hallsworth, M., Halpern, D., King, D., & Vlaev, I. (2010). MINDSPACE: influencing behaviour for public policy.

Dombrowski, S. U., Sniehotta, F. F., Avenell, A., Johnston, M., MacLennan, G., & Araújo-Soares, V. (2012). Identifying active ingredients in complex behavioural interventions for obese adults with obesity-related co-morbidities or additional risk factors for co-morbidities: A systematic review. *Health Psychology Review*, *6*(1), 7-32.

Dudziński, D. M., Bhatia, R. S., Mi, M. Y., Isselbacher, E. M., Picard, M. H., & Weiner, R. B. (2016). Effect of educational intervention on the rate of rarely appropriate outpatient echocardiograms ordered by attending academic cardiologists: a randomized clinical trial. *JAMA Cardiology*, *1*(7), 805-812.

Dur, R., & Vollaard, B. (2013). The power of a bad example: A field experiment in household garbage disposal. *Environment and Behavior*. (TILEC Discussion Paper No. 2013-037). Retrieved from SSRN http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2100372.

eMarketer. (2017). *Smartphone use headed for a new milestone in the UK*. Retrieved from https://www.emarketer.com/Article/Smartphone-Use-Headed-New-Milestone-UK/1016444

Emeakaroha, A., Ang, C. S., Yan, Y., & Hopthrow, T. (2014). Integrating persuasive technology with energy delegates for energy conservation and carbon emission reduction in a university campus. *Energy*, *76*, 357-374.

Enders, W. (2008). *Applied econometric time series*. John Wiley & Sons.

Eurostat. (2014). *Waste generation by economic activities and households, EU-28, 2014 (%) YB17.* Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Waste_generation_by_economic_activities_and_households,_EU-28,_2014_(%25)_YB17.png

Evans, J. S. B. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology*, *59*, 255-278.

Finnie, W C. (1973). Field experiments in litter control. *Environment and Behavior, 5*,123-144.

Fishbein, M. (1980). A theory of reasoned action: Some applications and implications. In H. Howe & M. Page (Eds.), *Nebraska Symposium on Motivation* (Vol. 27, pp. 65–116). Lincoln, NB: University of Nebraska Press.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*. Reading, MA: Addison Wesley.

Fisher, W. R. (1989). Human communication as narration: Toward a philosophy of reason, value, and action.

Fleming, A., Bradley, C., Cullinan, S., & Byrne, S. (2014). Antibiotic prescribing in long-term care facilities: A qualitative, multidisciplinary investigation. *BMJ Open*, *4*(11), e006442.

Francis, J. J., O'Connor, D., & Curran, J. (2012). Theories of behaviour change synthesised into a set of theoretical groupings: Introducing a thematic series on the theoretical domains framework. *Implementation Science*, *7*(1), 35.

Frederick, S., Loewenstein, G., & O'Donoghue, T. (2002). Time discounting and time preference: A critical review. *Journal of Economic Literature*, *40*(2), 351-401.

Frederick, S., Novemsky, N., Wang, J., Dhar, R., & Nowlis, S. (2009). Opportunity cost neglect. *Journal of Consumer Research*, *36*(4), 553-561.

Friedman, M. (2007). The social responsibility of business is to increase its profits. In *Corporate ethics and corporate governance* (pp. 173-178). Springer, Berlin, Heidelberg.

Gainforth, H. L., Sheals, K., Atkins, L., Jackson, R., & Michie, S. (2016). Developing interventions to change recycling behaviors: A case study of applying behavioral science. *Applied Environmental Education & Communication*, *15*(4), 325-339.

Garcia-Retamero, R., & Cokely, E.T. (2011). Effective communication of risks to young adults: using message framing and visual aids to increase condom use and STD screening. *Journal of Experimental Psychology: Applied, 17*, 270–287.

Gardner, B., Smith, L., Lorencatto, F., Hamer, M., & Biddle, S. J. H. (2016). How to reduce sitting time? A review of behaviour change strategies used in sedentary behaviour reduction interventions among adults. *Health Psychology Review*, *10*(1), 89–112.

Geller, E. S. Witmer, J. E, & Tuso, M. A. (1977). Environmental interventions for litter control. *Journal of Applied Psychology, 62*, 344- 351.

Gnich, W., Bonetti, D., Sherriff, A., Sharma, S., Conway, D. I., & Macpherson, L. (2015). Use of the theoretical domains framework to further

understanding of what influences application of fluoride varnish to children's teeth: a national survey of general dental practitioners in Scotland. *Community Dentistry and Oral Epidemiology*, *43*(3), 272-281.

Goldstein, N. J., Cialdini, R. B., & Griskevicius, V. (2008). A room with a viewpoint: Using social norms to motivate environmental conservation in hotels. *Journal of consumer Research*, *35*(3), 472-482

Gong, J., Zhang, Y., Yang, Z., Huang, Y., Feng, J., & Zhang, W. (2013). The framing effect in medical decision-making: a review of the literature. *Psychology, Health & Medicine*, *18*(6), 645–653.

Governance & Accountability Institute (20 March, 2018). *Report: 85% of S&P 500 Index® Companies Publish Sustainability Reports in 2017*. Retrieved from https://www.ga-institute.com/press-releases/article/flash-report-85-of-sp-500-indexR-companies-publish-sustainability-reports-in-2017.html

Gould, G. S., Bar-Zeev, Y., Bovill, M., Atkins, L., Gruppetta, M., Clarke, M. J., & Bonevski, B. (2017). Designing an implementation intervention with the Behaviour Change Wheel for health provider smoking cessation care for Australian Indigenous pregnant women. *Implementation Science*, *12*(1), 114.

Greaney, M. L., Sprunck-Harrild, K., Bennett, G. G., Puleo, E., Haines, J., Viswanath, K. V., & Emmons, K. M. (2012). Use of email and telephone prompts to increase self-monitoring in a Web-based intervention: randomized controlled trial. *Journal of Medical Internet Research*, *14*(4).

Griffin, J. B., Struempler, B., Funderburk, K., Parmer, S. M., Tran, C., & Wadsworth, D. D. (2018). My Quest, an intervention using text messaging to improve dietary and physical activity behaviors and promote weight loss in low-income women. *Journal of Nutrition Education and Behavior*, *50*(1), 11-18.

Grossman, M. (1973). On the concept of health capital and the demand for health. *Journal of Political Economy, 80,* 223–255.

Gujarati, D. N. (2009). *Basic econometrics*. Tata McGraw-Hill Education.

Gunter, L., Protopopova, A., Hooker, S. P., Der Ananian, C., & Wynne, C. D. (2017). Impacts of encouraging dog walking on returns of newly adopted dogs to a shelter. *Journal of Applied Animal Welfare Science*, *20*(4), 357-371.

Hageman, P. A., Noble Walker, S., & Pullen, C. H. (2005). Tailored versus standard internet-delivered interventions to promote physical activity in older women. *Journal of Geriatric Physical Therapy*, *28*(1), 28–33.

Hallsworth, M. (2017). *Increasing compliance in policy settings by applying psychological theories of behaviour to message design* (PhD dissertation).

Halpern, D. (2016). *Inside the nudge unit: How small changes can make a big difference*. Random House.

Hanks, Andrew S., David Just and Brian Wansink (2013). Smarter lunchrooms can address new school lunchroom guidelines and childhood obesity. *Journal of Pediatrics, 162*(4), 867-869.

Hartmann, D. P., Gottman, J. M., Jones, R. R., Gardner, W., Kazdin, A. E., & Vaught, R. S. (1980). Interrupted time-series analysis and its application to behavioral data. *Journal of Applied Behavior Analysis*, *13*(4), 543-559.

Hawn, C. (2009). Take two aspirin and tweet me in the morning: How Twitter, Facebook, and other social media are reshaping health care. *Health affairs*, *28*(2), 361-368.

Henrich, J., Boyd, R., Bowles, S., Camerer, C., Fehr, E., Gintis, H., ... & Henrich, N. S. (2005). "Economic man" in cross-cultural perspective: Behavioral experiments in 15 small-scale societies. *Behavioral and Brain Sciences, 28*(6), 795-815.

HM Government (2017). Litter strategy for England. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/630999/litter-strategy-for-england-2017-v2.pdf

HM Revenue and Customs. (2013). *Levelling the playing field: Compliance progress report*. London, The Stationery Office.

Hollands, G. J., Shemilt, I., Marteau, T. M., Jebb, S. A., Kelly, M. P., Nakamura, R., ... & Ogilvie, D. (2013a). Altering micro-environments to change population health behaviour: towards an evidence base for choice architecture interventions. *BMC Public Health*, *13*(1), 1218.

Hollands, G. J., Shemilt, I., Marteau, T. M., Jebb, S. A., Kelly, M. P., Nakamura, R., ... & Ogilvie, D. (2013b). Altering choice architecture to change population health behaviour: a large-scale conceptual and empirical scoping review of interventions within micro-environments. *Behaviour and Health Research Unit Working Paper*.

Hollands, G.J., Shemilt, I., Marteau, T.M., Jebb, S.A., Lewis, H.B., Wei, Y., Ogilvie, D. (2015). *Portion, package or tableware size for changing selection and consumption of food, alcohol and tobacco*. London: Cochrane Database of Systematic Review.

Houston, T. K., Sadasivam, R. S., Allison, J. J., Ash, A. S., Ray, M. N., English, T. M., ... & Ford, D. E. (2015). Evaluating the QUIT-PRIMO clinical practice ePortal to increase smoker engagement with online cessation interventions: a national hybrid type 2 implementation study. *Implementation Science*, *10*(1), 154.

HubBub (n.d.). *Campaigns*. Retrieved from https://www.hubbub.org.uk /Pages/Category/campaigns

Huijg, J. M., Dusseldorp, E., Gebhardt, W. A., Verheijden, M. W., van der Zouwe, N., Middelkoop, B. J., ... & Crone, M. R. (2015). Factors associated with physical therapists' implementation of physical activity interventions in the Netherlands. *Physical Therapy*, *95*(4), 539-557.

Huijg, J. M., Gebhardt, W. A., Crone, M. R., Dusseldorp, E., & Presseau, J. (2014). Discriminant content validity of a theoretical domains framework questionnaire for use in implementation research. *Implementation Science*, *9*(11), 1–16.

Hutchesson, M. J., Tan, C. Y., Morgan, P., Callister, R., & Collins, C. (2016). Enhancement of self-monitoring in a web-based weight loss program by extra individualized feedback and reminders: Randomized trial. *Journal of Medical Internet Research*, *18*(4).

Incorporated by Royal Charter. (2017). *Adults spend almost 8 hours each day consuming media*. Retrieved from http://www.ipa.co.uk/news/adults-spend-almost-8-hours-each-day-consuming-media#.W0cj5tgzY18

ING (n.d.). *About ING eZonmics*. Retrieved from https://www.ezonomics .com/about/

Joireman, J., Shaffer, M. J., Balliet, D., & Strathman, A. (2012). Promotion orientation explains why future-oriented people exercise and eat healthy: Evidence from the two-factor consideration of future consequences-14 scale. *Personality and Social Psychology Bulletin*, *38*(10), 1272–1287.

Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in intuitive judgment. In: T. Gilovich, D. Griffin and D.

Kahneman (Eds). *Heuristics and biases: The Psychology of Intuitive Judgment*. New York: Cambridge University Press.

Kahneman, D. & Snell, J. (1990). Predicting utility. In R.M. Hogarth (Ed.), *Insights in decision making: A tribute to Hillel J. Einhorn*. Chicago, IL: University of Chicago Press.

Kahneman, D., & Tversky, A. (1973). On the psychology of prediction. *Psychological Review*, *80*(4), 237.

Kahneman, D., & Tversky, A. (1984). Choices, values and frames. *American Psychologist*, *39*(4), 341–350.

Kahneman, D., Wakker, P. P., & Sarin, R. (1997). Back to Bentham? Explorations of experienced utility. *The Quarterly Journal of Economics*, *112*(2), 375-406.

Kang, M., Rochford, A., Skinner, R., Mindel, A., Webb, M., Peat, J., & Usherwood, T. (2012). Facilitating chlamydia testing among young people: A randomised controlled trial in cyberspace. *Sexually Transmitted Infections*, *88*(8), 568–573.

Karlan, D., McConnell, M., Mullainathan, S. & Zinman, J. (2016). Getting to the top of mind: How reminders increase saving. *Management Science, 62*(12), 3393-3411.

Kattelmann, K. K., Bredbenner, C. B., White, A. A., Greene, G. W., Hoerr, S. L., Kidd, T., ... & Brown, O. N. (2014). The effects of Young Adults Eating and Active for Health (YEAH): A theory-based Web-delivered intervention. *Journal of Nutrition Education and Behavior*, *46*(6), S27-S41.

Keep Britain Tidy. (2014a). *Keeping an eye on it: A social experiment to combat dog fouling*. Retrieved from http://www.keepbritaintidy.org /sites/default/files/ resource/Keeping%20an%20eye%20on %20it_Final%20report.pdf

Keep Britain Tidy. (2014b). *The wider cost of litter*. Wigan.

Keep Britain Tidy. (2015). *How clean is England? The Local Environmental Quality Survey of England 2014/15.*

Keep Britain Tidy. (n.d.) *Resources and Publications*. Retrieved from http://www.keepbritaintidy.org/ centre-for-social-innovation/research-library

Keysar, B., Hayakawa, S. L., An, S. G. (2012). The foreign-language effect: Thinking in a foreign tongue reduces decision biases. *Psychological Science*, *23*(6), 661–68.

Khambalia, A. Z., Dickinson, S., Hardy, L. L., Gill, T. A., & Baur, L. A. (2012). A synthesis of existing systematic reviews and meta-analyses of school-based behavioural interventions for controlling and preventing obesity. *Obesity Reviews*, *13*(3), 214-233.

Khwaja, A., Silverman, D., & Sloan, F. (2007). Time preference, time discounting, and smoking decisions. *Journal of Health Economics*, *26*(5), 927–49.

Kolodko, J. & Read D. (2018). Using behavioural science to reduce littering: Understanding, addressing and solving the problem of litter using a commons dilemma approach. *Journal of Litter and Environmental Quality, 2*(1), 21-36.

Kothe, E. J., & Mullan, B. A. (2014a). Acceptability of a theory of planned behaviour email-based nutrition intervention. *Health Promotion International*, *29*(1), 81–90.

Kothe, E. J., & Mullan, B. A. (2014b). A randomised controlled trial of a theory of planned behaviour to increase fruit and vegetable consumption. Fresh Facts. *Appetite*, *78*, 68-75.

Kothe, E. J., Mullan, B. A., & Butow, P. (2012). Promoting fruit and vegetable consumption. Testing an intervention based on the theory of planned behaviour. *Appetite*, *58*(3), 997-1004.

Kramer, J. N., & Kowatsch, T. (2017). Using feedback to promote physical activity: The role of the feedback sign. *Journal of Medical Internet Research*, *19*(6).

Krauss, R. M, Freedman, J. L, & Whitcup, M. (1978). Field and laboratory studies of littering. *Journal of Experimental Social Psychology, 14*,109-122.

Leone, L. A., Allicock, M., Pignone, M. P., Walsh, J. F., Johnson, L. S., Armstrong-Brown, J., ... & Campbell, M. K. (2016). Cluster randomized trial of a church-based peer counselor and tailored newsletter intervention to promote colorectal cancer screening and physical activity among older African Americans. *Health Education & Behavior*, *43*(5), 568-576.

Leung, S., Zheng, W.Y., Sandhu, A., Day, R., Li, L. and Baysari, M. (2017). Feedback and training to improve use of an electronic prescribing system: A randomised controlled trial. In *Integrating and connecting care: Selected papers from the 25th Australian National Health Informatics Conference, 239*.

Levenson, J. C., Miller, E., Hafer, B. L., Reidell, M. F., Buysse, D. J., & Franzen, P. L. (2016). Pilot study of a sleep health promotion program for college students. *Sleep Health: Journal of the National Sleep Foundation*, *2*(2), 167-174.

Levinson, J., & Peng, K. (2007). Valuing cultural differences in behavioral economics. *ICFAI Journal of Behavioral Finance, 4,* 32-47.

Liebrand, W., Messick, D., & Wilke, H. (1992). *Social dilemmas: Theoretical issues and research findings*. Garland Science.

Limaye, T., Kumaran, K., Joglekar, C., Bhat, D., Kulkarni, R., Nanivadekar, A., & Yajnik, C. (2017). Efficacy of a virtual assistance-based lifestyle intervention in reducing risk factors for Type 2 diabetes in young employees in the information technology industry in India: LIMIT, a randomized controlled trial. *Diabetic Medicine*, *34*(4), 563-568.

LitterGram. (n.d.). *Help share our story*. Retrieved from https://www.littergram.co.uk/our-story-press

Loewenstein, G., & Prelec, D. (1991). Negative time preference. *The American Economic Review*, *81*(2), 347-352.

Loewenstein, G. F., & Prelec, D. (1993). Preferences for sequences of outcomes. *Psychological Review*, *100*(1), 91.

Magen, E., Dweck, C.S., Gross, J.J. (2008). The Hidden zero effect: Representing a single choice as an extended sequence reduces impulsive choice. *Psychological Science, 19*(7), 648–649.

Magen, E., Kim, B., Dweck, C. S., Gross, J. J., & McClure, S. M. (2014). Behavioral and neural correlates of increased self-control in the absence of increased willpower. *Proceedings of the National Academy of Sciences*, *111*(27), 9786-9791.

Manikam, L., Hoy, A., Fosker, H., Wong, M. H. Y., Banerjee, J., Lakhanpaul, M., ... & Littlejohns, P. (2015). What drives junior doctors to use clinical practice guidelines? A national cross-sectional survey of foundation doctors in England & Wales. *BMC Medical Education*, *15*(1), 227.

Marine Conservation Society (2017). Annual Impact Report & Accounts, 2016-2017. Retrieved from https://www.mcsuk.org/media/annualreport/Annual_Impact_Report_and_Accounts_2016-2017.pdf

Martin, S.J., Goldstein, N., Cialdini, R. (2014). *The small big: Small changes that spark big influence*. Profile Books.

McCullough, A. R., Ryan, C., O'Neill, B., Bradley, J. M., Elborn, J. S., & Hughes, C. M. (2015). Defining the content and delivery of an intervention to Change AdhereNce to treatment in BonchiEctasis (CAN-BE): a qualitative approach incorporating the Theoretical Domains Framework, behavioural change techniques and stakeholder expert panels. *BMC Health Services Research*, *15*(1), 342.

Mc Sharry, J., Murphy, P. J., & Byrne, M. (2016). Implementing international sexual counselling guidelines in hospital cardiac rehabilitation: development of the CHARMS intervention using the Behaviour Change Wheel. *Implementation Science*, *11*(1), 134.

Meyerowitz, B.E., & Chaiken, S. (1987). The effect of message framing on breast self-examination attitudes, intentions, and behavior. *Journal of Personality and Social Psychology, 52*, 500–510.

Michie, S., Atkins, L., & West, R. (2014). *The Behaviour Change Wheel: A Guide to Designing Interventions*. London: Silverback Publishing.

Michie, S., & Johnston, M. (2012). Theories and techniques of behaviour change: Developing a cumulative science of behaviour change. *Health Psychology Review, 6*(1), 1-6.

Michie, S., Johnston, M., Francis, J., Hardeman, W., & Eccles, M. (2008). From theory to intervention: mapping theoretically derived behavioural determinants to behaviour change techniques. *Applied Psychology*, *57*(4), 660-680.

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., ... & Wood, C. E. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine*, *46*(1), 81-95.

Michie, S. F., West, R., Campbell, R., Brown, J., & Gainforth, H. (2014b). *ABC of behaviour change theories*. Silverback Publishing.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, *63*(2), 81.

Mokdad, A.H., Marks, J.S., Stroup, D.F., & Gerberding, J.L. (2000). Actual causes of death in the United States. *Journal of the American Medical Association, 293*(3), 293-294.

Moreira, M. T., Oskrochi, R., & Foxcroft, D. R. (2012). Personalised normative feedback for preventing alcohol misuse in university students: Solomon three-group randomised controlled trial. *PloS One*, *7*(9), e44120.

Morgan, A. J., Mackinnon, A. J., & Jorm, A. F. (2013). Behavior change through automated e-mails: Mediation analysis of self-help strategy use for depressive symptoms. *Behaviour Research and Therapy*, *51*(2), 57-62.

Murphy, M. E., Byrne, M., Zarabzadeh, A., Corrigan, D., Fahey, T., & Smith, S. M. (2017). Development of a complex intervention to promote appropriate prescribing and medication intensification in poorly controlled type 2 diabetes mellitus in Irish general practice. *Implementation Science*, *12*(1), 115.

Murphy, B. L., & DiPietro, N. A. (2012). Impact of a pharmacist-directed educational program on the long-term knowledge and use of folic acid among college women: A 12-month follow-up study. *Pharmacy Practice*, *10*(2), 105.

Nakamura, R., Pechey, R., Suhrcke, M., Jebb, S. A., & Marteau, T. M. (2014). Sales impact of displaying alcoholic and non-alcoholic beverages in end-of-aisle locations: An observational study. *Social Science & Medicine*, *108*, 68-73.

Ngamruengphong, S., Horsley-Silva, J. L., Hines, S. L., Pungpapong, S., Patel, T. C., & Keaveny, A. P. (2015). Educational Intervention in Primary Care Residents' Knowledge and Performance of Hepatitis B Vaccination in Patients with Diabetes Mellitus. *Southern medical journal*, *108*(9), 510-515.

NHS. (2016). *Top sources of added sugar in our diet*. Retrieved from https://www.nhs.uk/live-well/eat-well/top-sources-of-added-sugar/

NHS Digital, (2017). Statistics on Obesity, Physical Activity and Diet - England, 2017. Retrieved from http://webarchive.nationalarchives.gov.uk/20180328133908/http://digital.nhs.uk/catalogue/PUB23742

Noar, S. M., & Zimmerman, R. S. (2005). Health Behavior Theory and cumulative knowledge regarding health behaviors: Are we moving in the right direction? *Health Education Research*, *20*(3), 275-290.

O'Brien, N., McDonald, S., Araújo-Soares, V., Lara, J., Errington, L., Godfrey, A., ... & Sniehotta, F. F. (2015). The features of interventions associated with long-term effectiveness of physical activity interventions in adults aged 55–70 years: A systematic review and meta-analysis. *Health Psychology Review*, *9*(4), 417-433.

OECD. (2017). *Behavioural Insights and Public Policy: Lessons from Around the World*.

Office for National Statistics (2017, May 19). Internet users in the UK: 2017. How internet use is correlated to various socio-demographic characteristics, such as age, sex, disability and geographical location. Retrieved from https://www.ons.gov.uk/businessindustryandtrade /itandinternetindustry/bulletins/internetusers/2017

O'Keefe, D. J., & Jensen, J. D. (2009). The relative persuasiveness of gain-framed and loss-framed messages for encouraging disease detection behaviors: A meta-analytic review. *Journal of Communication*, *59*(2), 296–316.

Oosterbeek, H., Sloof, R., & Van De Kuilen, G. (2004). Cultural differences in ultimatum game experiments: Evidence from a meta-analysis. *Experimental Economics*, *7*(2), 171-188.

Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science*, *349*(6251), aac4716.

Ouellette, J. A., Hessling, R., Gibbons, F. X., Reis-Bergan, M., & Gerrard, M. (2005). Using images to increase exercise behavior: Prototypes versus possible selves. *Personality and Social Psychology Bulletin*, *31*(5), 610-620.

Parrott, M. W., Tennant, L. K., Olejnik, S., & Poudevigne, M. S. (2008). Theory of Planned Behavior: Implications for an email-based physical activity intervention. *Psychology of Sport and Exercise*, *9*(4), 511–526.

Pearson, N., Atkin, A. J., Biddle, S. J. H., & Gorely, T. (2010). A family-based intervention to increase fruit and vegetable consumption in adolescents: A pilot study. *Public Health Nutrition*, *13*(6), 876–885.

Peer, E., Samat, S., Brandimarte, L., & Acquisti, A. (2016). Beyond the Turk: An empirical comparison of alternative platforms for crowdsourcing online behavioral research. Retrieved from https://ssrn.com/abstract=2594183

Petersen, J. E., Shunturov, V., Janda, K., Platt, G., & Weinberger, K. (2007). Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives. *International Journal of Sustainability in Higher Education*, *8*(1), 16-33.

Petty, R., & Cacioppo, J. (1986). The elaboration likelihood model of persuasion. *Advances in Experimental Social Psychology*, *19*, 123–183.

Petrella, R. J., Gill, D. P., Zou, G., De, A. C., Riggin, B., Bartol, C., ... & Bunn, C. (2017). Hockey fans in training: A pilot pragmatic randomized controlled trial. *Medicine and Science in Sports and Exercise*, *49*(12), 2506-2516.

Piko, B. F., & Brassai, L. (2009). The role of individual and familial protective factors in adolescents' diet control. *Journal of Health Psychology*, *14*(6), 810-819.

Platt, J. (1973). Social traps. *American Psychologist, 28,* 641-651.

Plontikoff, R. (2005). Efficacy of an e-mail intervention for the promotion of physical activity and nutrition behavior in the workplace context. *American Journal of Health Promotion*, (July).

Plotnikoff, R. C., Pickering, M. A., McCargar, L. J., Loucaides, C. A., & Hugo, K. (2010). Six-month follow-up and participant use and satisfaction of an electronic mail intervention promoting physical activity and nutrition. *American Journal of Health Promotion*, *24*(4), 255–259.

Poddar, K. H., Hosig, K. W., Anderson-Bill, E. S., Nickols-Richardson, S. M., & Duncan, S. E. (2012). Dairy intake and related self-regulation improved in college students using online nutrition education. *Journal of the Academy of Nutrition and Dietetics*, *112*(12), 1976-1986.

Prestwich, A., Sniehotta, F. F., Whittington, C., Dombrowski, S. U., Rogers, L., & Michie, S. (2014). Does theory influence the effectiveness of health behavior interventions? Meta-analysis. *Health Psychology*, *33*(5), 465–474.

Radu, P. T., Yi, R., Bickel, W. K., Gross, J. J., & McClure, S. M. (2011). A mechanism for reducing delay discounting by altering temporal attention. *Journal of the experimental analysis of behavior*, *96*(3), 363-385.

Read, D. (2001). Intrapersonal dilemmas. *Human Relations*, *54*(8), 1093–1117.

Read, D., Olivola, C. & Hardisty, D. (2016). The value of nothing: Asymmetric attention to opportunity costs drives intertemporal decision making. *Management Science,* 1-22.

Read, D., & Scholten, M. (2012). Tradeoffs between sequences: weighing accumulated outcomes against outcome-adjusted delays. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(6), 1675.

Readability Formulas (n.d.). Retrieved from http://www.readabilityformulas .com/free-readability-formula-tests.php

Reiter, S. M., & Samuel, W (1980). Littering as a function of prior litter and the presence or absence of prohibitive signs. *Journal of Applied Social Psychology, 10*, 45-5.

Reno, R. R., Cialdini, R. B., & Kallgren, C. A. (1993). The transsituational influence of social norms. *Journal of personality and social psychology*, *64*(1), 104.

Rivis, A., & Sheeran, P. (2003). Descriptive norms as an additional predictor in the theory of planned behaviour: A meta-analysis. *Current Psychology*, *22*(3), 218-233.

Rodda, S. N., Dowling, N. A., Knaebe, B., & Lubman, D. I. (2017). Does SMS improve gambling outcomes over and above access to other e-mental health supports? A feasibility study. *International Gambling Studies*, 1-15.

Robertson, A. (2016). Effects of a social media website on primary care givers' awareness of music therapy services in a neonatal intensive care unit. *The Arts in Psychotherapy*, *50*, 17-21.

Robinson, J. K., Guevara, Y., Gaber, R., Clayman, M. L., Kwasny, M. J., Friedewald, J. J., & Gordon, E. J. (2014). Efficacy of a sun protection workbook for kidney transplant recipients: a randomized controlled trial of a culturally sensitive educational intervention. *American Journal of Transplantation*, *14*(12), 2821-2829.

Rompotis, C. J., Grove, J. R., & Byrne, S. M. (2014). Benefits of habit-based informational interventions: A randomised controlled trial of fruit and vegetable consumption. *Australian and New Zealand Journal of Public Health*, *38*(3), 247–252.

Rothman, A.J., Martino, S.C., Bedell, B.T., De tweiler, J.B., & Salovey, P. (1999). The systematic influence of gain- and loss-framed messages on interest in and use of different types of health behavior. *Personality and Social Psychology Bulletin, 25*, 1355–1369.

Schelling, T.C. (1978). *Micromotives and macrobehavior*. New York: Norton.

Schneider, K. L., Murphy, D., Ferrara, C., Oleski, J., Panza, E., Savage, C., ... & Lemon, S. C. (2015). An online social network to increase walking in dog owners: A randomized trial. *Medicine and Science in Sports and Exercise*, *47*(3), 631.

Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychological science*, *18*(5), 429-434.

Schweier, R., Romppel, M., Richter, C., & Grande, G. (2016). Dissemination strategies and adherence predictors for web-based interventions—how efficient are patient education sessions and email reminders?. *Health Education Research*, *31*(3), 384-394.

Seward, K., Wolfenden, L., Wiggers, J., Finch, M., Wyse, R., Oldmeadow, C., ... & Yoong, S. L. (2017). Measuring implementation behaviour of menu guidelines in the childcare setting: Confirmatory factor analysis of a theoretical domains framework questionnaire (TDFQ). *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 45.

Shapiro, J. R., Koro, T., Doran, N., Thompson, S., Sallis, J. F., Calfas, K., & Patrick, K. (2012). Text4Diet: A randomized controlled study using text messaging for weight loss behaviors. *Preventive Medicine*, *55*(5), 412–417.

Short, C. E., James, E. L., Girgis, A., D'souza, M. I., & Plotnikoff, R. C. (2015). Main outcomes of the Move More for Life Trial: A randomised controlled trial examining the effects of tailored-print and targeted-print materials for promoting physical activity among post-treatment breast cancer survivors. *Psycho-Oncology*, *24*(7), 771-778.

Short, C. E., Rebar, A. L., & Vandelanotte, C. (2015). Do personalised e-mail invitations increase the response rates of breast cancer survivors invited to participate in a web-based behaviour change intervention? A quasi-randomised 2-arm controlled trial. *BMC Medical Research Methodology*, *15*(1), 66.

Simon, H. A. (1982). *Models of bounded rationality: Empirically grounded economic reason* (Vol. 3). MIT press.

Simons-Morton, B. G., Hartos, J. L., Leaf, W. A., & Preusser, D. F. (2005). Persistence of effects of the checkpoints program on parental restrictions of teen driving privileges. *American Journal of Public Health*, *95*(3), 447–452.

Singapore Health Promotion Board (2016). The Straits Times. Retrieved from http://www.straitstimes.com/singapore/health/hpb-steering-singaporeans-to-eat-healthier

Skoien, W., Page, K., Parsonage, W., Ashover, S., Milburn, T., & Cullen, L. (2016). Use of the Theoretical Domains Framework to evaluate factors driving successful implementation of the Accelerated Chest pain Risk Evaluation (ACRE) project. *Implementation Science*, *11*(1), 136.

Skolarus, T. A., Metreger, T., Hwang, S., Kim, H. M., Grubb, R. L., Gingrich, J. R., & Hawley, S. T. (2017). Optimizing veteran-centered prostate cancer survivorship care: study protocol for a randomized controlled trial. *Trials*, *18*(1), 181.

Smith, A., de Salas, K., Schüz, B., Ferguson, S. G., & Lewis, I. (2016, November). mHealth intervention design: creating mHealth interventions for behaviour change. In *Proceedings of the 28th Australian Conference on Computer-Human Interaction* (pp. 531-536). ACM.

Smith, R., Corrigan, P., and Exeter, C. (2012). *Countering non-communicable disease through innovation. Report of the non-communicable disease working group*. London: The Global Helath Policy Summit.

Sousa Lourenco, J., Ciriolo, E., Almeida, S., & Troussard, X. (2016). Behavioural insights applied to policy.

Staddon, S. C., Cycil, C., Goulden, M., Leygue, C., & Spence, A. (2016). Intervening to change behaviour and save energy in the workplace: A systematic review of available evidence. *Energy Research & Social Science*, *17*, 30-51.

Stanovich, K. E. (1999). *Who is rational?: Studies of individual differences in reasoning*. Psychology Press.

Statista (2018a). Average number of litter items collected per 100 meters of beach in the United Kingdom (UK) from 2016 to 2017, by country.

Retrieved from https://www.statista.com/statistics/790350/collected-beach-litter-united-kingdom/

Statista (2018b). Number of Twitter users in the United Kingdom (UK) from 2012 to 2018 (in million users). Retrieved from https://www.statista.com/statistics/271350/twitter-users-in-the-united-kingdom-uk/

Statista. (2018c). *Share of individuals sending and receiving e-mails in Great Britain from 2012 to 2017*. Retrieved from https://www.statista.com/statistics/286206/e-mail-messaging-penetration-in-great-britain/

Steinmo, S., Fuller, C., Stone, S. P., & Michie, S. (2015). Characterising an implementation intervention in terms of behaviour change techniques and theory: The 'Sepsis Six' clinical care bundle. *Implementation Science*, *10*(1), 111.

Strathman, A., Gleicher, F., Boninger, D. S., & Edwards, C. S. (1994). The consideration of future consequences: Weighing immediate and distant outcomes of behavior. *Journal of Personality and Social Psychology*, *66*(4), 742–752.

Suntornsut, P., Wongsuwan, N., Malasit, M., Kitphati, R., Michie, S., Peacock, S. J., & Limmathurotsakul, D. (2016). Barriers and recommended interventions to prevent melioidosis in northeast Thailand: A focus group study using the behaviour change wheel. *PLoS Neglected Tropical Diseases*, *10*(7), e0004823.

SwissRe (n.d.) How behavioural science is helping improve the way we do insurance. Retrieved from http://www.swissre.com/clients/introducing_behavioural_economics.html

Tang, J. C. H., Abraham, C., Greaves, C. J., & Nikolaou, V. (2016). Self-directed interventions to promote weight loss: a systematic review and meta-analysis. *Health Psychology Review*, *10*(3), 358–372.

Tavarez, M. M., Ayers, B., Jeong, J. H., Coombs, C. M., Thompson, A., & Hickey, R. (2017). Practice variation and effects of e-mail only performance feedback on resource use in the Emergency Department. *Academic Emergency Medicine*.

Taylor, N., Lawton, R., & Conner, M. (2013). Development and initial validation of the determinants of physical activity questionnaire. *International Journal of Behavioral Nutrition and Physical Activity*, *10*(1), 74.

Taylor, N., Lawton, R., Slater, B., & Foy, R. (2013). The demonstration of a theory-based approach to the design of localized patient safety interventions. *Implementation Science*, *8*(1), 123.

Templeton, A. R., Young, L., Bish, A., Gnich, W., Cassie, H., Treweek, S., ... & Clarkson, J. (2015). Patient-, organization-, and system-level barriers and facilitators to preventive oral health care: a convergent mixed-methods study in primary dental care. *Implementation Science*, *11*(1), 5.

Thaler, R. H., & Sunstein, C. R. (2003). Libertarian paternalism. *American Economic Review*, *93*(2), 175-179.

Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth, and happiness*. New York: Penguin Books.

Timmerman, L., Stronks, D. L., & Huygen, F. J. (2017). The design of a theory-based intervention to improve medication adherence in chronic pain patients. *Current Medical Research and Opinion*, *33*(7), 1293-1301.

Tombor, I., Shahab, L., Brown, J., Crane, D., Michie, S., & West, R. (2016). Development of SmokeFree Baby: a smoking cessation smartphone app for pregnant smokers. *Translational Behavioral Medicine*, *6*(4), 533–545.

Triandis, H. C. (1977). *Interpersonal behaviour*. Monterey, CA: Brooks/Cole.

Trockel, M., Manber, R., Chang, V., Thurston, A., & Tailor, C. B. (2011). An e-mail delivered CBT for sleep-health program for college students: Effects on sleep quality and depression symptoms. *Journal of Clinical Sleep Medicine*, *7*(3), 276–281.

Turcotte, D. L., & Rundle, J. B. (2002). Self-organized complexity in the physical, biological, and social sciences.

Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology*, *5*(2), 207-232.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *science*, *185*(4157), 1124-1131.

Tversky, A. & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science, 211*, 453–458.

United Nations (2011). *Draft political declaration of the high-level meeting on the prevention and control of NCDs*. New York.

van Dijk, M. R., Oostingh, E. C., Koster, M. P., Willemsen, S. P., Laven, J. S., & Steegers-Theunissen, R. P. (2017). The use of the mHealth program Smarter Pregnancy in preconception care: Rationale, study design and

data collection of a randomized controlled trial. *BMC Pregnancy and Childbirth*, *17*(1), 46.

Van Ittersum, K., & Wansink, B. (2011). Plate size and color suggestibility: the Delboeuf Illusion's bias on serving and eating behavior. *Journal of Consumer Research*, *39*(2), 215-228.

Voshaar, M., Vriezekolk, J., van Dulmen, S., van den Bemt, B., & van de Laar, M. (2016). Barriers and facilitators to disease-modifying antirheumatic drug use in patients with inflammatory rheumatic diseases: A qualitative theory-based study. *BMC Musculoskeletal Disorders*, *17*(1), 442.

Wakefield, M. A., Loken, B., & Hornik, R. C. (2010). Use of mass media campaigns to change health behaviour. *The Lancet*, *376*(9748), 1261-1271.

Walker, S. N., Pullen, C. H., Boeckner, L., Hageman, P. A., Hertzog, M., Oberdorfer, M., & Rutledge, M. J. (2009). Clinical trial of tailored activity and eating newsletters with older rural women. *Nursing ResearchNursing Research*, *58*(2), 74–85.

Walker, S., Pullen, C. H., Hageman, P. A., Boeckner, L., Hertzog, M., Oberdorfer, M., & Rutledge, M. J. (2010). Maintenance of activity and eating change following a clinical trial of tailored newsletters with older rural women. *Nursing Research*, *59*(5), 311–321.

Webb, J., Hall, J., Hall, K., & Fabunmi-Alade, R. (2016). Increasing the frequency of physical activity very brief advice by nurses to cancer patients. A mixed methods feasibility study of a training intervention. *Public Health*, *139*, 121–133.

Webb, T. L., Joseph, J., Yardley, L., & Michie, S. (2010). Using the Internet to promote health behavior change: A systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. *Journal of Medical Internet Research*, *12*(1), 1–18.

Webb, T. L., & Sheeran, P. (2006). Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. *Psychological Bulletin*, *132*(2), 249–268.

Webster, R., Michie, S., Estcourt, C., Gerressu, M., Bailey, J. V., & MenSS Trial Group. (2015). Increasing condom use in heterosexual men: Development of a theory-based interactive digital intervention. *Translational Behavioral Medicine*, *6*(3), 418-427.

Wells, L., de Salas, K., Lewis, I., & Berry, A. (2016). Behaviour change wheel driven normative feedback in a serious game for energy conservation. In: *First International Joint Conference of DiGRA and FDG (DiGRA/FDG'16)* (pp. 1-16).

Westland, H., Bos-Touwen, I. D., Trappenburg, J. C., Schröder, C. D., de Wit, N. J., & Schuurmans, M. J. (2017). Unravelling effectiveness of a nurse-led behaviour change intervention to enhance physical activity in patients at risk for cardiovascular disease in primary care: Study protocol for a cluster randomised controlled trial. *Trials*, *18*(1), 79.

Wilson, C., & Marselle, M. R. (2016). Insights from psychology about the design and implementation of energy interventions using the Behaviour Change Wheel. *Energy Research & Social Science*, *19*, 177-191.

Witte, K., & Allen, M. (2000). A meta-analysis of fear appeals: Implications for effective public health campaigns. *Health Education & Behavior*, *27*(5), 591–615.

World Bank. (2015). *World development report 2015: Mind, society, and behavior*.

World Health Organization (2017a). *Noncommunicable diseases fact sheet*. Retrieved from http://www.who.int/mediacentre/factsheets/fs355/en/

World Health Organization (2017b). *Obesity and overweight fact sheet*. Retrieved from http://www.who.int/mediacentre/factsheets/fs311/en/

Wu, C. Y., & He, G. B. (2012). The effects of time perspective and salience of possible monetary losses on intertemporal choice. *Social Behavior and Personality: an international journal*, *40*(10), 1645-1653.

Yates, B. C., Pullen, C. H., Santo, J. B., Boeckner, L., Hageman, P. A., Dizona, P. J., & Walker, S. N. (2012). The influence of cognitive-perceptual variables on patterns of change over time in rural midlife and older women's healthy eating. *Social Science and Medicine*, *75*(4), 659–667.

Young, W., Russell, S. V., Robinson, C. A., & Barkemeyer, R. (2017). Can social media be a tool for reducing consumers' food waste? A behaviour change experiment by a UK retailer. *Resources, Conservation and Recycling*, *117*, 195-203.

Young, C. W., Russell, S. V., Robinson, C. A., & Chintakayala, P. K. (2018). Sustainable retailing–influencing consumer behaviour on food waste. *Business Strategy and the Environment*, *27*(1), 1-15.

Zwickert, K., Rieger, E., Swinbourne, J., Manns, C., McAulay, C., Gibson, A. A., ... & Caterson, I. D. (2016). High or low intensity text-messaging combined with group treatment equally promote weight loss maintenance in obese adults. *Obesity research & clinical practice*, *10*(6), 680-691.

APPENDIX A

Original vs. simplified CFC statements used in Hidden Consequences study

Table 1
Original vs. simplified CFC statements used in Hidden Consequences study.

Original CFC Statement	Simplified CFC Statement
I consider how things might be in the future, and try to influence those things with my day to day behaviour.	I think about how things might be in the future, and try to influence them with my behaviour.
Often I engage in a particular behaviour in order to achieve outcomes that may not result for many years.	I often do things to achieve outcomes that may not happen for many years.
I only act to satisfy immediate concerns, figuring the future will take care of itself.	I only act for the present. The future will take care of itself.
My behaviour is only influenced by the immediate (i.e., a matter of days or weeks) outcomes of my actions.	My actions are only influenced by the effects they will have in a matter of days or weeks.
My convenience is a big factor in the decisions I make or the actions I take.	Convenience is a big factor in what I choose and what I do.
I am willing to sacrifice my immediate happiness or well-being in order to achieve future outcomes.	I will sacrifice immediate happiness to achieve long term outcomes.
I think it is important to take warnings about negative outcomes seriously even if the negative outcome will not occur for many years.	We should pay attention to warnings, even when they are about things that will not occur for many years.
I think it is more important to perform a behaviour with important distant consequences than a behaviour with less important immediate consequences.	It is better to do things with large delayed effects than things with small immediate effects.
I generally ignore warnings about possible future problems because I think the problems will be resolved before they reach crisis level.	I usually ignore warnings about possible future problems. They can be resolved later, before they reach crisis level.
I think that sacrificing now is usually unnecessary since future outcomes can be dealt with at a later time.	Sacrifices here and now are usually unnecessary. We can deal with the future later.
I only act to satisfy immediate concerns, figuring that I will take care of future problems that may occur at a later date.	I only act to satisfy immediate concerns. I will take care of future problems at a later date.
Since my day to day work has specific outcomes, it is more important to me than behaviour that has distant outcomes.	My day to day work has immediate effects. It is more important to me than behaviour with distant outcomes.
When I make a decision, I think about how it might affect me in the future.	I always think about how my choices might affect me in the future.
My behaviour is generally influenced by future consequences.	My behaviour is usually influenced by the future.

APPENDIX B

Hidden Consequences
Study 2 Materials

Figure 1
Group 1 instructions.

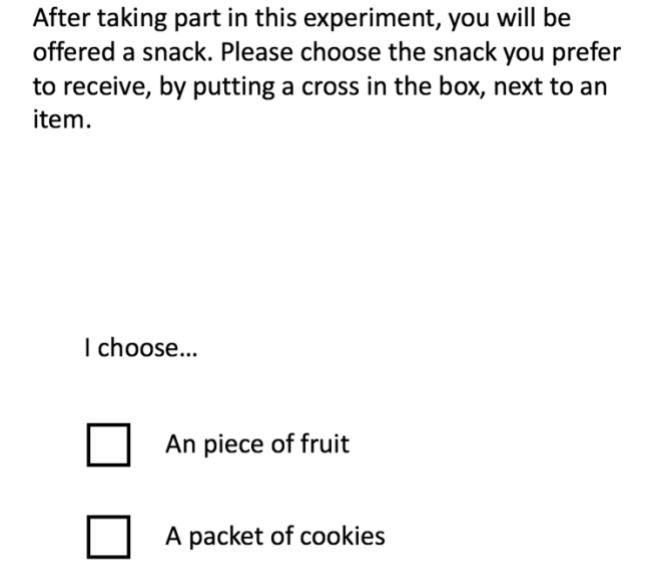


Figure 2.
Group 2 instructions.

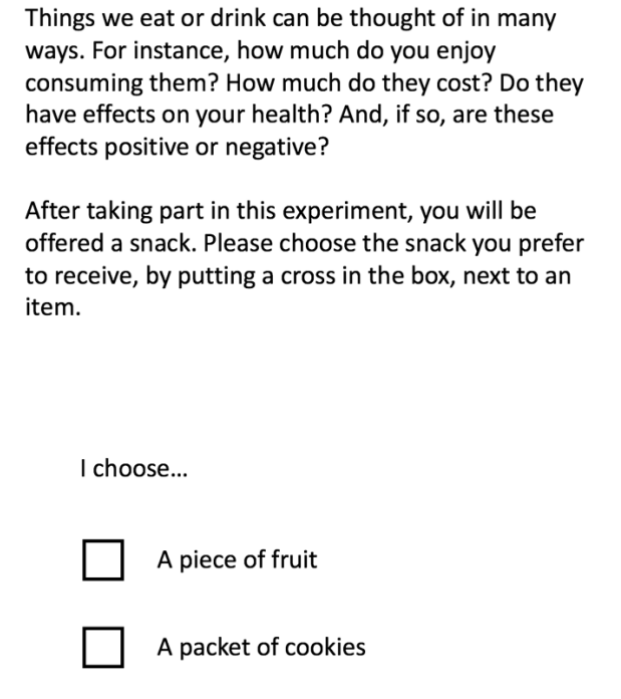


Figure 3
Group 3 instructions.

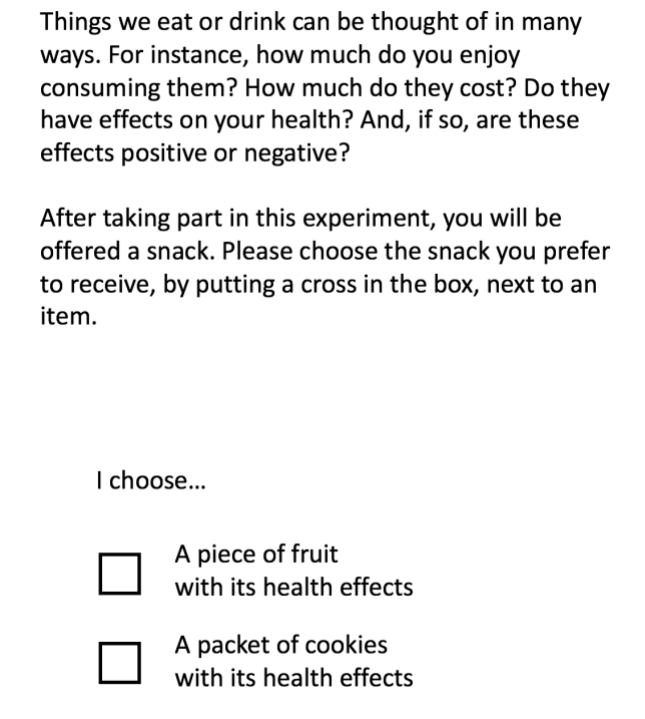


Figure 4
Group 4 instructions.

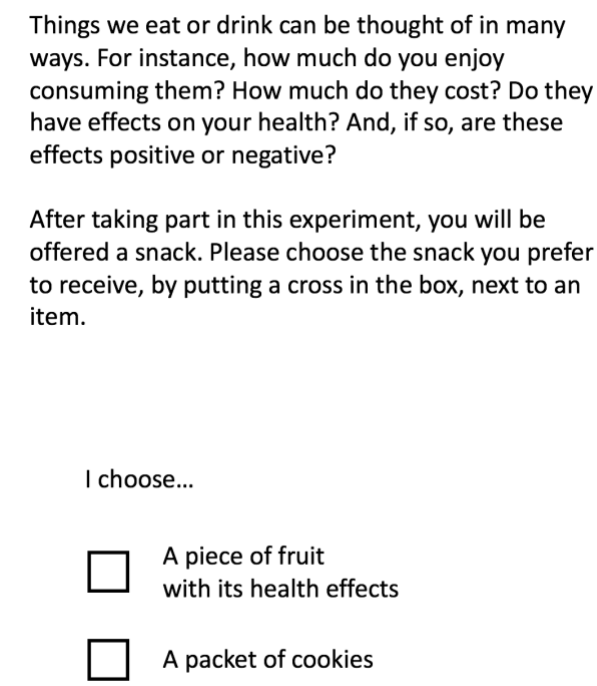
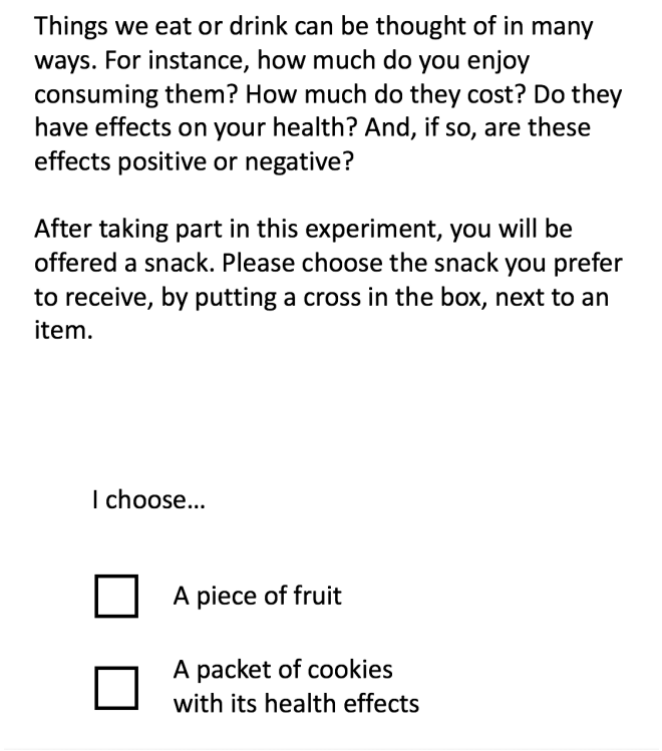


Figure 5
Group 5 instructions.



APPENDIX C

Twitter Study Materials

Table 1
Twitter Study 1.1 TDF statements.

Sources of Behaviour (COM-B Model)		TDF	Statements
Capability	Psychological	*Knowledge*	I know what is the objective of posting anti-littering messages on Twitter.*
			I know how to write a post on Twitter.
			I know how to post a picture on Twitter.
		Cognitive and interpersonal skills	I have experience posting on Twitter.
			I have the skills necessary to post anti-littering messages on Twitter.
		Memory, attention and decision processes	I often intent to post an anti-littering message on Twitter and then forget to do it.
			There often are distractions online, or around me, which prevent me from posting anti-littering messages on Twitter.
			It is easy for me to select an anti-littering topic to Tweet about.*
		Behavioural regulation	Posting anti-littering messages on Twitter is something I would automatically, without thinking.
			I can keep track of my overall progress in posting anti-littering messages on Twitter, e.g. by keeping track of the number of posts I tweet.
Opportunity	Social	*Social influences*	Most people who are important to me would think it is a good idea for me to post anti-littering messages on Twitter.
			I know other people who post anti-littering messages on Twitter.
	Physical	*Environmental context and resources*	I regularly use a smart phone.
			Often there are times, for example at work or in school, when I have no access to Twitter.
Motivation	Reflective	*Social/professional role and identity*	As an influential person, it is my job to post anti-littering messages on Twitter.
			Posting anti-littering messages on Twitter is consistent with who I am.
		Beliefs about capabilities	I can post anti-littering messages on Twitter even if other people are not motivated to do so.
			I can post anti-littering messages on Twitter even if I have little time.
		Optimism	I feel optimistic about the impact that posting anti-littering messages on Twitter can have.
		Intention	I will definitely post an anti-littering message on Twitter in the next seven days.
		Goals	I have an idea of what anti-littering messages I will post on Twitter.
			I know under what circumstances I will post anti-littering messages on Twitter.
			Posting anti-littering messages on Twitter is often less urgent than doing other things.*

		Beliefs about consequences	Posting anti-littering messages on Twitter can make a change.
			Posting anti-littering messages on Twitter will have a positive effect on people in my social network.
	Automatic	*Reinforcement*	Having my anti-littering Tweets retweeted, or liked, by other people would motivate me to post even more such messages.
			I would get recognition from people who are important to me if I posted anti-littering messages on Twitter.
			Getting monetary rewards, or other incentives, for posting anti-littering messages on Twitter would motivate me to do it more often.
		Emotion	Posting anti-littering messages on Twitter would make me feel good.
			Posting anti-littering messages on Twitter is boring or annoying.

* Statements marked with an asterisk were removed from the analysis after conducting a Cronbach-Alpha analysis. See the *Internal consistency of TDF scales* section in Chapter 3.

Table 2
Twitter Study 2.1 TDF statements.

Sources of Behaviour (COM-B Model)		TDF	Statements
Capability	Psychological	*Knowledge*	I know how to write an anti-littering post on Twitter.
			I know how to post an anti-littering picture on Twitter.
		Cognitive and interpersonal skills	I have the skills and ability necessary to post anti-littering messages on Twitter.
			I have experience posting on Twitter.
		Memory, attention and decision processes	I usually have no distractions to prevent me from posting anti-littering messages on Twitter.
			It is easy to remember to post anti-littering messages on Twitter.
		Behavioural regulation	I would post anti-littering tweets automatically, without even thinking about it.
			I could keep track of how much I use Twitter to post anti-littering messages.
Opportunity	Social	*Social influences*	Most people would think it is a good idea for me to post anti-littering messages on Twitter.
			I know other people who post anti-littering messages on Twitter.
	Physical	*Environmental context and resources*	Most of the time I have access to Twitter.
			I regularly use a smart phone.
Motivation	Reflective	*Social/professional role and identity*	As an influential person, it is my job to post anti-littering messages on Twitter.
			Posting anti-littering messages on Twitter is consistent with who I am.
		Beliefs about capabilities	I can post anti-littering messages on Twitter even if other people are not motivated to do so.
			I can post anti-littering messages on Twitter even if I have little time.
		Optimism	I expect posting an anti-littering message to have a positive impact.
			I feel optimistic about the impact that posting anti-littering messages on Twitter can have.
		Intention	Within the next week I intend to post an anti-littering message on Twitter.
			I will definitely post an anti-littering message on Twitter in the next seven days.
		Goals	I know the type of anti-littering messages I will post on Twitter.
			I know under what circumstances I will post anti-littering messages on Twitter.
		Beliefs about consequences	Posting anti-littering messages on Twitter can make a change.

			Posting anti-littering messages on Twitter will have a positive effect on people in my social network.
	Automatic	*Reinforcement*	I am motivated to post anti-littering messages by the recognition I would get from people who are important to me.
			I am motivated to post anti-littering messages on Twitter by the retweets I might earn.
		Emotion	Posting anti-littering messages on Twitter would make me feel positive.
			Posting anti-littering messages on Twitter would make me feel good.

Figure 1
Step 1 of Behavioural rehearsal/practice *BCT used in Study 2.2.*

Figure 2
Step 2 of Behavioural rehearsal/practice *BCT used in Study 2.2.*

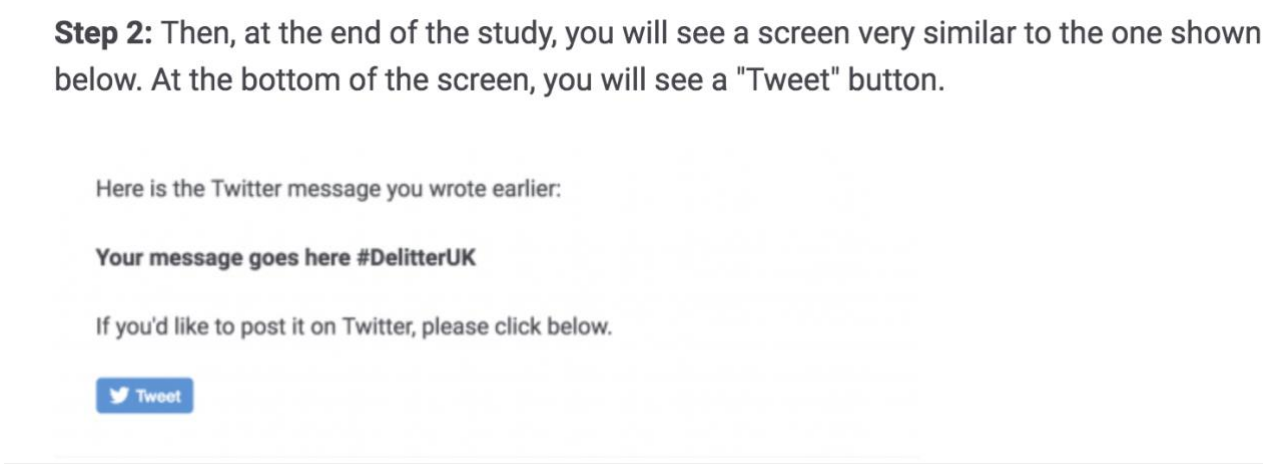


Figure 3
Step 3 of Behavioural rehearsal/practice *BCT used in Study 2.2.*

Figure 4
Anticipation of future reward *BCT used in Study 2.2.*

APPENDIX D

LitterGram Study Materials

Table 1
LitterGram TDF statements.

Sources of Behaviour (COM-B Model)		TDF	Statements
Capability	Psychological	*Knowledge*	I know that the goal of LitterGram is to become a tool through which local councils are notified of litter, so that they can clean it up.
			I know how to post on LitterGram.
		Cognitive and interpersonal skills	I have the skills necessary to use LitterGram.
			I have prior experience posting on LitterGram.
		Memory, attention and decision processes	I often forget to post on LitterGram.
			There are often distractions online, or around me, which prevent me from posting on LitterGram.
			It is easy for me to decide whether what I see is "litter" and, therefore, whether I should post a picture of it on LitterGram.*
		Behavioural regulation	Posting on LitterGram is something I would do automatically, without thinking.
			I can keep track of my overall progress in using LitterGram, i.e. the number of pictures I post.
			I would monitor whether the litter of which I post pictures on LitterGram does get cleaned up by my local council.
Opportunity	Social	*Social influences*	Most people who are important to me would think it is a good idea to post on LitterGram.
			I know other people who post on LitterGram.
	Physical	*Environmental context and resources*	My local council knows about LitterGram.
			My local council reacts to what is being posted on LitterGram.
			I regularly use a smart phone.*
Motivation	Reflective	*Social/professional role and identity*	Posting on LitterGram is part of my responsibility as a LitterGram user.
			Posting on LitterGram is consistent with who I am.
		Beliefs about capabilities	I can post on LitterGram even if other people are not motivated to do so.
			I can post on LitterGram even if I have little time.
		Optimism	I feel optimistic about the impact that posting on LitterGram can have.
		Intention	I will post on LitterGram in the next seven days.
		Goals	I have an idea of what pictures to post on LitterGram.
			I know under what circumstances to post on LitterGram.

			Posting on LitterGram is often less urgent for me than doing other things.*
		Beliefs about consequences	Posting on LitterGram will benefit the place where I live.
			Posting on LitterGram can make a change.
			If I post on LitterGram, the litter will get cleaned up by a local council.*
			The more I post on LitterGram, the greater the chance that a local council will clean up the litter.
	Automatic	*Reinforcement*	I would get recognition from people who are important to me if I posted on LitterGram.
			Getting material rewards, or other incentives, for posting on LitterGram would motivate me to do it more often.
			If I knew that litter I post pictures of does get cleaned up by a local council, I'd use LitterGram more often.
		Emotion	Posting on LitterGram makes me feel good.
			Posting on LitterGram is boring or annoying.

* Statements marked with an asterisk were removed from the analysis after conducting a Cronbach-Alpha analysis. See the *Internal consistency of TDF scales* section in Chapter 4.

Table 2
LitterGram intervention e-mail schedule.

Time		Group 1 dates	Group 2 dates	BCT	E-mail content
Week 1	Friday	16 Jun 2017	30 Jun 2017	*Social and environmental consequences*	First of six e-mails with information on positive consequences of posting on LitterGram *or* negative consequences of not posting on LitterGram
	Tuesday	20 Jun 2017	4 Jul 2017	*(Monitoring of) Emotional consequences*	First of six e-mails with a request to evaluate how posting/not posting on LitterGram in the previous seven days made the person feel
	Thursday	22 Jun 2017	6 Jul 2017	*Self-monitoring of behaviour*	First of six e-mails with information on how many pictures the person posted in the last seven days
Week 2	Friday	23 Jun 2017	8 Jul 2017	*Social and environmental consequences*	Second of six e-mails with information on positive consequences of posting on LitterGram *or* negative consequences of not posting on LitterGram
	Tuesday	27 Jun 2017	12 Jul 2017	*(Monitoring of) Emotional consequences*	Second of six e-mails with a request to evaluate how posting/not posting on LitterGram in the previous seven days made the person feel
	Thursday	29 Jun 2017	13 Jul 2017	*Self-monitoring of behaviour*	Second of six e-mails with information on how many pictures the person posted in the last seven days
Week 3	Friday	30 Jun 2017	14 Jul 2017	*Social and environmental consequences*	Third of six e-mails with information on positive consequences of posting on LitterGram *or* negative consequences of not posting on LitterGram
	Tuesday	4 Jul 2017	19 Jul 2017	*(Monitoring of) Emotional consequences*	Third of six e-mails with a request to evaluate how posting/not posting on LitterGram in the previous seven days made the person feel
	Thursday	6 Jul 2017	21 Jul 2017	*Self-monitoring of behaviour*	Third of six e-mails with information on how many pictures the person posted in the last seven days
Week 4	Friday	8 Jul 2017	22 Jul 2017	*Social and environmental consequences*	Fourth of six e-mails with information on positive consequences of posting on LitterGram *or* negative consequences of not posting on LitterGram
	Tuesday	12 Jul 2017	25 Jul 2017	*(Monitoring of) Emotional consequences*	Fourth of six e-mails with a request to evaluate how posting/not posting on LitterGram in the previous seven days made the person feel
	Thursday	13 Jul 2017	27 Jul 2017	*Self-monitoring of behaviour*	Fourth of six e-mails with information on how many pictures the person posted in the last seven days
Week 5	Friday	14 Jul 2017	28 Jul 2017	*Social and environmental consequences*	Fifth of six e-mails with information on positive consequences of posting on LitterGram *or* negative consequences of not posting on LitterGram

	Tuesday	19 Jul 2017	1 Aug 2017	*(Monitoring of) Emotional consequences*	Fifth of six e-mails with a request to evaluate how posting/not posting on LitterGram in the previous seven days made the person feel
	Thursday	21 Jul 2017	3 Aug 2017	*Self-monitoring of behaviour*	Fifth of six e-mails with information on how many pictures the person posted in the last seven days
Week 6	Friday	22 Jul 2017	4 Aug 2017	*Social and environmental consequences*	Sixth of six e-mails with information on positive consequences of posting on LitterGram *or* negative consequences of not posting on LitterGram
	Tuesday	25 Jul 2017	8 Aug 2017	*(Monitoring of) Emotional consequences*	Sixth of six e-mails with a request to evaluate how posting/not posting on LitterGram in the previous seven days made the person feel
	Thursday	26 Jul 2017	10 Aug 2017	*Self-monitoring of behaviour*	Sixth of six e-mails with information on how many pictures the person posted in the last seven days
Post-intervention survey		8 Aug 2017	22 Aug 2017	-	First e-mail with the post-intervention survey link
		17 Aug 2017	31 Aug 2017	-	Second e-mail with the post-intervention survey link

Figure 1
E-mails with TDF survey link.

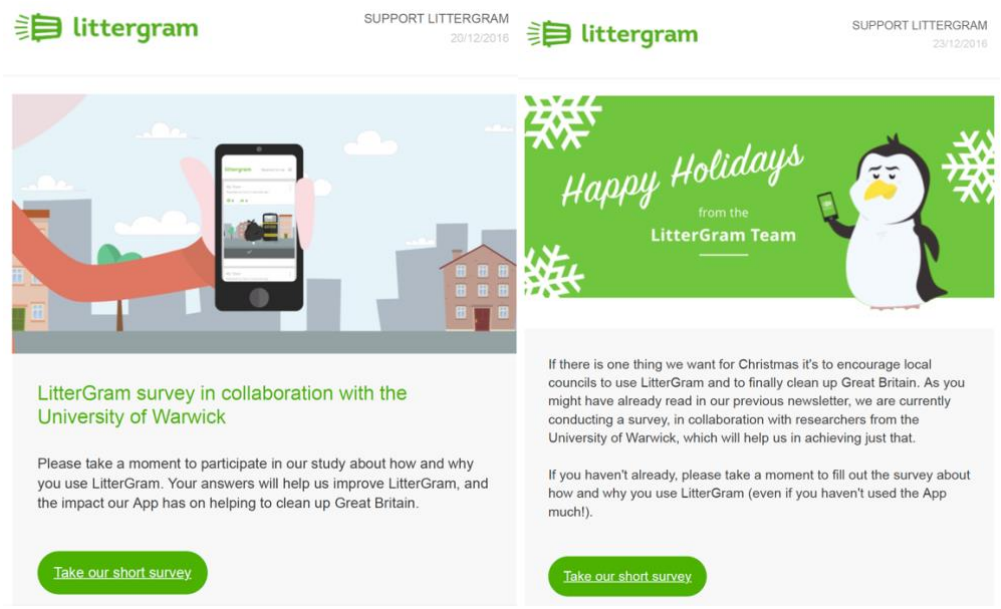


Figure 2
Positive frame e-mails with Social and environmental consequences *message/BCT*.

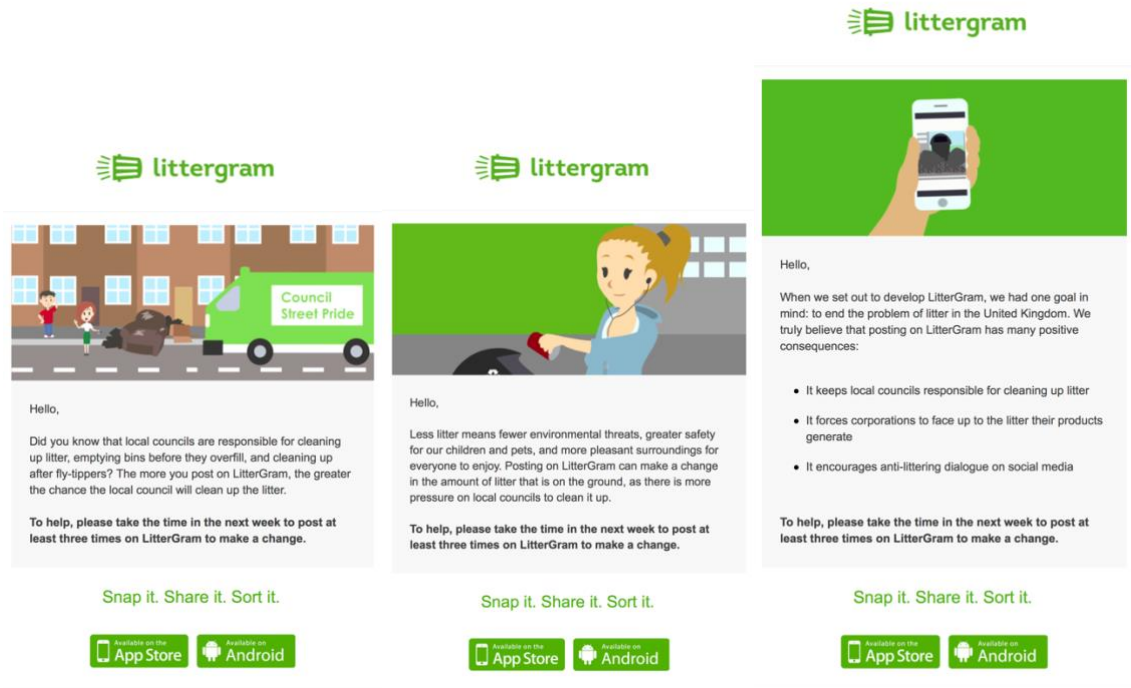


Figure 3
Negative frame e-mails with Social and environmental consequences *message/BCT*.

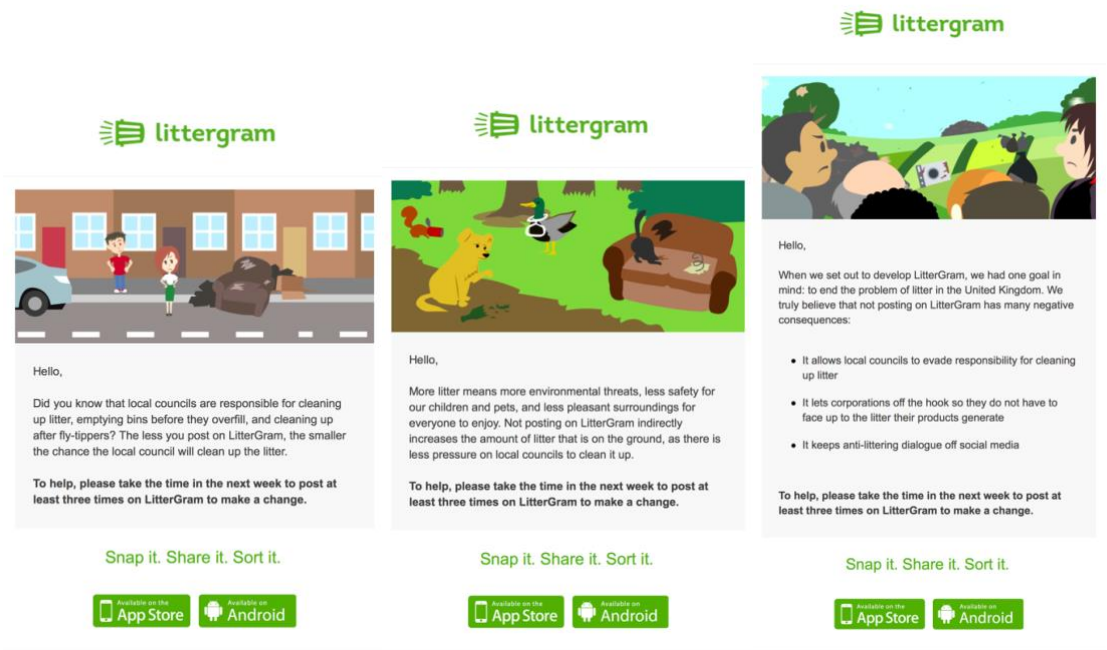


Figure 4
Example e-mail with (Monitoring of) Emotional consequences *message/BCT*.

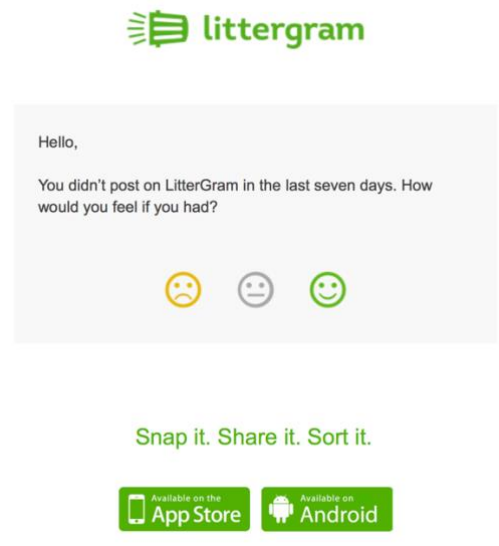


Figure 5
Example e-mail with Self-monitoring of behaviour *message/BCT.*

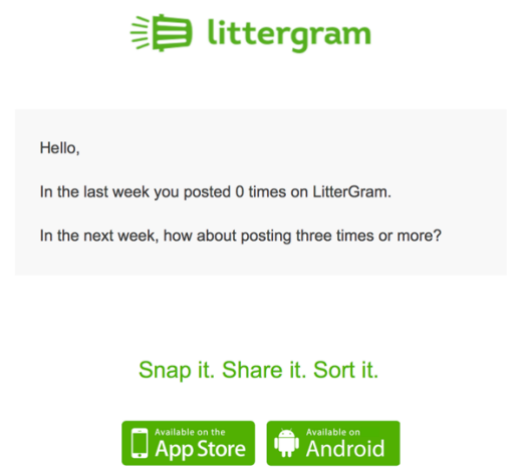


Figure 6
E-mails with a request to participate in the manipulation check study.

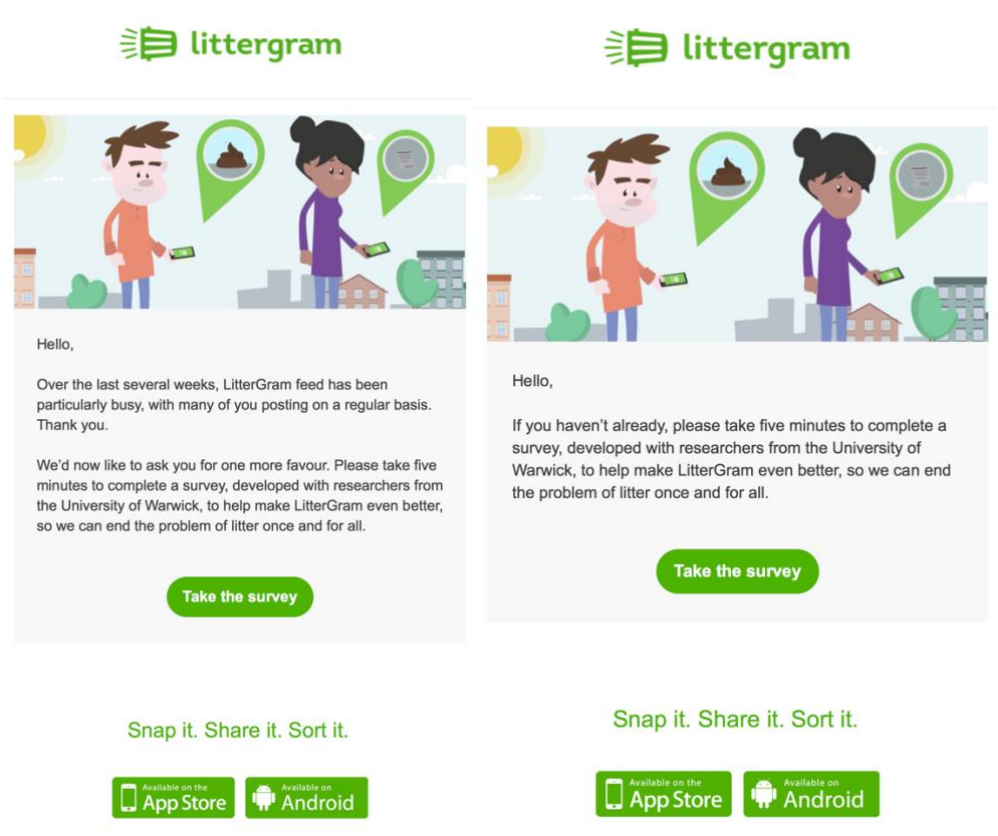


Figure 7
Ljung-Box test statistics for residuals.

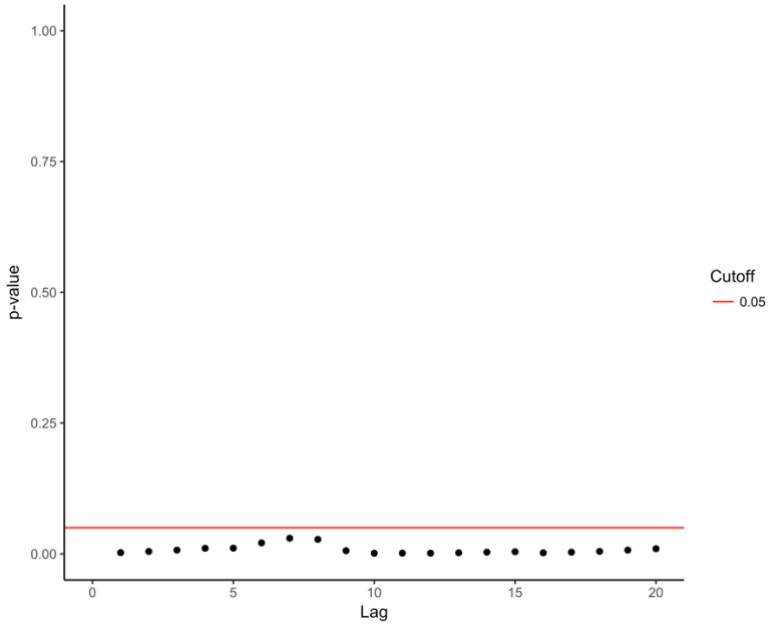


Figure 8
ACF and PACF residuals.

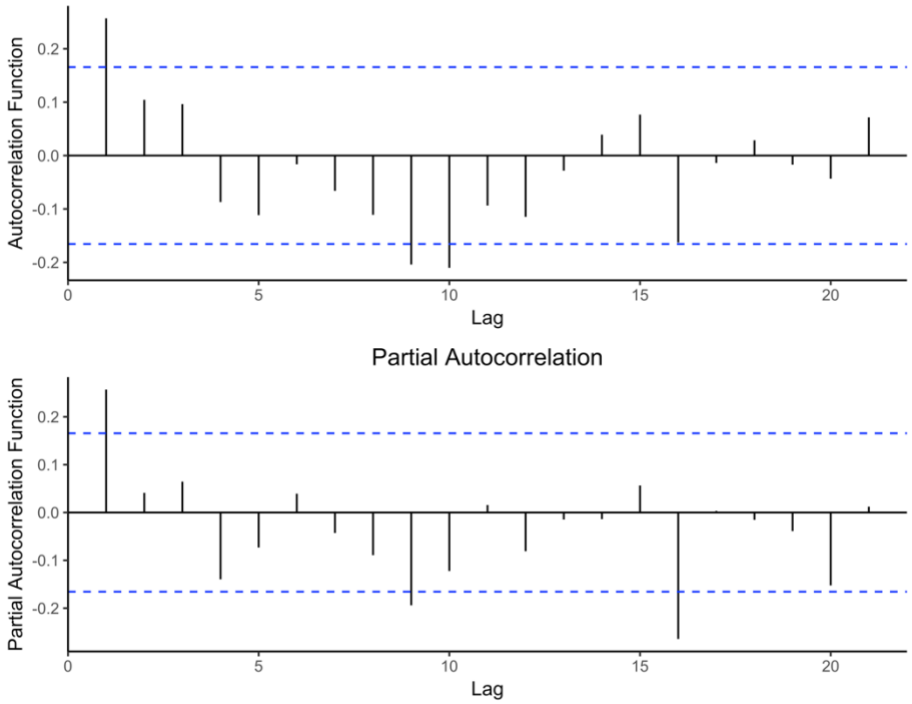


Figure 9
ARIMA Box-Jenkins test statistics for residuals.

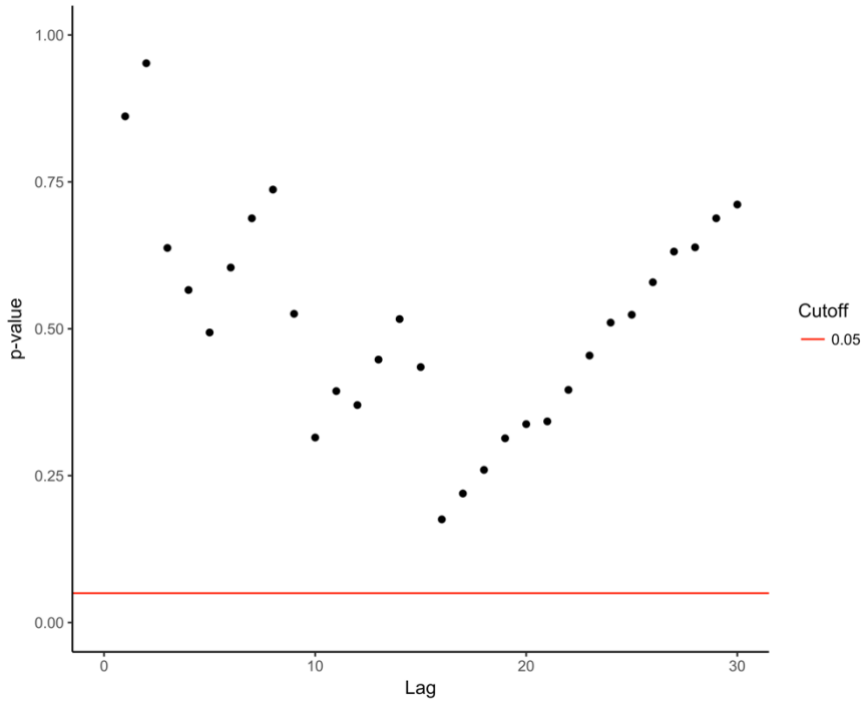


Figure 10
ARIMA ACF and PACF residuals.